Compressed Air

A MONTHLY MAGAZINE DEVOTED TO THE USEFUL APPLICATION OF COMPRESSED AIR.

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"Compressed Air,"

OR

THE COMPRESSED AIR MAGAZINE.

A MONTHLY PUBLICATION DEVOTED TO THE USEFUL APPLICATION OF COMPRESSED AIR.

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Compressed Air and Electricity for Coal Mines.

From the first time it was put into practical service many centuries ago, compressed air has labored at a disadvantage. Air is such a common thing; it is here, there and everywhere, to be obtained without trouble, that it does not get the attention that its more spectacular neighbor, electricity, receives. Steam has had a like advantage over compressed air. There is no doubt that the pneumatic engineer is called upon to meet working conditions that would not be tolerated for a moment by the electrical or steam expert.

It is well that compressed air can work with success under distinctly unfavorable conditions. It is manifestly unfair, however, to compare the results under these conditions with those achieved by electricity or steam when working with every possible economic advantage. Comparisons are essential to engineering practice. The only solution of many an engineering problem is a comparison of results. But it is equally essential that this comparison shall be fair. Both sides must be on an equal footing.

In the October number of *Mines and Minerals* there appeared a paper by Mr. W. B. Clarke, in reply to one by the editor of this publication. Mr. Clarke makes a comparison between an electric and a compressed air power plant for a coal mine. At a cursory glance it would appear that Mr. Clarke had successfully demonstrated the superiority of electricity. A careful examination of his paper shows how unfair is the comparison which he has made. The electric plant referred to is one operating under advanced methods and so designed as to secure all possible economies. Compressed air, on the contrary, is operating in an old plant under adverse conditions, where the only wonder is that it has done so well. The fallacy of Mr. Clarke's comparison is shown in a communication by Mr. Geo. R. Murray, one of the most experienced pneumatic engineers of the country. We publish Mr. Clarke's paper in this issue, following it with Mr. Murray's comment.

As Mr. Clarke's paper deals largely with the use of compressed air in coal mines, a paper on a "Comparison of Electric and Compressed Air Locomotives in American Mines," by Beverley S. Randolph, read before the Institution of Mining Engineers, England, is of timely interest. Mr. Randolph is an authority on pneumatic haulage. Mr. Randolph's paper, with the comments of the members of the Institution, is published in full. We also publish an article regarding it which appeared in the *Colliery Guardian*. Concluding this general discussion is an abstract of a paper read by Mr. A. De Geunes before the French Society of Civil Engineers.

This discussion brings prominently to the front the fact that in many cases compressed air is used uneconomically and with little attempt to attain the highest efficiency. Its effectiveness, when used under proper conditions, has been fully demonstrated during the last few years. An important factor in this demonstration has been the result of a central compressed air power plant, installed at North Amherst, O., by the Cleveland Stone Company. Here compressed air has been substituted for steam and some remarkable savings made. Many of the successful applications of the air under pressure have been combined to an extent never before attempted and with admitted success. The central compressed air power plant is no longer an experiment. It has proved its usefulness and economy, and the electrical and steam engineer must concede it its proper place.

Remedy for Freezing.

Our attention has been called to an inquiry from a user of compressed air complaining of freezing in the air pipes. The conditions are described as follows:

"Our receiver is inside the engine-room. Air line runs up grade from receiver for about 18 feet and is buried about 3 feet. Passing the 18-foot point it runs down grade away from receiver about 150 feet and there we have a drain cock. From the 18-foot point the 150-foot section is buried from 3 to 1½ feet, and the point that generally freezes is from 50 to 75 feet from the 18-foot point. We have found that the ground freezes as low or lower than the air line is laid at the point where it freezes. We had thought to let the 150-foot section down below frost and put the air receiver out of doors. Would that obviate the difficulty, and would it then be apt to freeze after passing the 150-foot sections?"

The only reliable way to prevent this freezing is to eliminate the moisture in the compressed air before it enters the pipe line. This is best done by use of an aftercooler, which is simply a tank containing a nest of tubes placed closely together. The air passing on the outside of the tubes is broken up into thin layers and the water circulating through the tubes effectively cools the temperature of the air, so that practically all of the moisture held in suspension is dropped to the bottom of the cooler.

An aftercooler can be secured from any compressor manufacturer, or one could be made up of an old tubular boiler which would probably answer the purpose.

It would be a good plan to place the air receiver out of doors as suggested, provided it would not be too far from the compressor cylinder, say 20 to 25 feet. This arrangement would probably take most of the moisture from the air. Rather than bury the air line in the ground, it would be a better plan to put a cheap box covering, filled with some non-conducting material, over the pipe.

In answer to the question as to whether freezing would take place if 150 feet of the pipe were below the frost line and the rest uncovered, we do not believe this would help to any extent, as the air would still be exposed to the cold, and whatever moisture was contained in the air would still be condensed and frozen as it is now. Of course, the greater the length of the pipe that was covered, the better the conditions would be, and if 500 feet were below frost line there would probably be less trouble; but even then it would be apt to freeze if it were any considerable distance from that point to the point of discharge. The proper thing to do is to pass the air through some sort of an aftercooler at the compressor house.

Electrical Apparatus for Coal Mines.

SOME FACTS AND COMPARISONS OF ELECTRIC HAULAGE AND PUMPING PLANTS WITH THOSE USING COMPRESSED AIR.*

At the Albany meeting, in February, 1903, I read a paper, entitled "Electrical Apparatus for Coal Mining." This title was somewhat misleading, since a comprehensive treatment of a broad subject might have been expected; but the paper was, in fact, limited by the announcement of two kindred papers, one by Mr. H. H. Stoek, on "Electricity in the Anthracite Coal Field," and the other by Mr. R. G. Hutchins, on "Electric Mine Haulage." It was my intention simply to point out the trend of recent developments in this branch of electrical engineering; and my paper accordingly described chiefly the application of high-voltage alternating-current transmission to coal mining, and an electric mine locomotive designed for gathering coal cars from the room faces. I was somewhat surprised, therefore, by the extended comments on my paper by Mr. Saunders, and I have not been able to find an earlier opportunity to reply.

Mr. Saunders remarks in his introduction that "there is no war between electricity and compressed air," but at the same time he assumes such an aggressive attitude that some of his statements should not pass unchallenged. Fifteen years ago compressed air had for a long time occupied this field without serious competition, and such electrical plants as were in operation were more or less experimental. Times have changed, however, and the extensive use of electrical apparatus in mining operations is an accomplished and indisputable fact.

Mr. Saunders has naturally played his best card first. The compressed-air rock drill, although very inefficient, is a rugged machine, capable of standing the most severe abuse, and, until a comparatively recent date, has had practically no competitor. During the past three years, however, several electric rock drills have been developed with more or less success. The principal advantage of the electric drill lies in its much higher efficiency. An ordinary 3-inch compressed-air rock drill indicates in the steam cylinders of the air compressor about 12 horse-power, while an electric drill working at the same rate requires from 3 to 4 indicated horse-power. The compressed-air drill has some advantage in its relative simplicity, but it attained long ago the height of its practical development, whereas the present types of electric rock drills are of comparatively recent design, and, considering the amount of energy and capital involved, it is reasonable to expect important further improvement in them.

Mr. Saunders quotes from the "Report of the Bureau of Mines of Pennsylvania for 1899" the statement that "the use of electricity in any form in coal mines is a menace to life, limb and property."

Conservatism is certainly a commendable virtue, but just as surely there is a point where persistent conservatism becomes retrogressive. The statement thus quoted is applicable with equal force to steam railroads or to the use of electricity for street railways or for illuminating purposes, or, in fact, to a thousand and one other essentials of modern civilization. Such sweeping statements indicate merely a lack of familiarity with electrical mining machinery; and in view of the present extensive and successful use of electrical apparatus in coal mining operations, Mr. Saunders' quotation has very little bearing on the present discussion.

Electric mine locomotives are not recommended for gaseous coal mines in which safety lamps are exclusively employed. Mines which are "hot" to this extent are comparatively few, and in this field the mine mule and the compressed-air locomotive may hold undisputed sway. In this connection, however, it should be noted that alternating-current induction motors are available for stationary service, in which there are no moving contacts liable to "spark," and that the dangers of igniting an explosive body of gas are no greater with these motors than with compressed-air machinery.

Mr. Saunders quotes an extract from a paper by Mr. A. D. Adams, entitled "The Difficulties Which Must Necessarily Be Met and Some Means of Reducing the Dangers of Faulty Insulation."

There are several wrong ways and a few right ways of installing electrical apparatus—a statement equally true of al-

* By W. B. Clarke in *Mines and Minerals*. A reply to the discussion by W. L. Saunders of the paper of W. B. Clarke, presented at the Albany meeting of the American Institute of Mining Engineers, February, 1903.

most every kind of machinery. Volumes have been written regarding the proper installation of air compressors, pipe lines and engines for mining service, but this is not an argument against the use of compressed air. At the Albany meeting of the Institute, for instance, Dr. Ledoux presented a paper, entitled "Notes on Accidents Due to Combustion Within Air Compressors," in which he cited an instance where "two men were killed and four others barely escaped with their lives." Mr. Saunders says, regarding that paper, that "Dr. Ledoux gives an interesting account of a serious accident which might occur in almost any mining plant, provided due precautions are not observed." It does not follow, however, that the use of compressed air underground is "a menace to life, limb and property."

Mr. Saunders devotes several paragraphs to the compressed-air mine locomotive, but it is apparent that his familiarity with this subject is not due to personal observation in the mines. In this connection, he remarks that in 1895 there were not more than six or seven compressed-air locomotives in service, "while to-day there are at least 150 of these locomotives in successful operation in mines," a record which will, he thinks, "compare favorably with that which can be shown by the manufacturers of electric mining locomotives."

The "Pennsylvania Report of the Bureau of Mines for 1902" is now available, and the following statistics have an interesting bearing on this discussion:

MINE LOCOMOTIVES IN THE BITUMINOUS AND ANTHRACITE DISTRICTS.

Bituminous	Steam	Compressed Air	Electric
1901	134	23	231
1902	130	16	326
Anthracite			
1901	362	51	40
1902	373	55	53

In the bituminous districts during 1902 the number of steam mine locomotives decreased 3 per cent., and that of compressed-air locomotives 44 per cent., while the number of electric mine locomotives increased 40 per cent. In the anthracite districts the report shows an increase in the number of steam and compressed-air mine locomotives of 3 per cent. and 8 per cent., respectively, while the number of electric mine locomotives increased 32 per cent. At the present writing, there are in the anthracite districts of Pennsylvania 113 electric mine locomotives, of which 36 are equipped with the cable reel, and are employed for "gathering" coal from cars from the room faces. (I may say here that at one time one of these 6.5-ton electric gathering locomotives hauled cars from the face of a "dipping" room, where the grade was so steep that four mules working tandem were required to haul out one loaded car.)

The first electric mine locomotive built in the United States was put in service in 1887, at the Lykens Valley Colliery of the Pennsylvania Railroad Company. A year later this machine was remodeled, and it is still in every-day service, its work during 1901 amounting to 531,584 ton-miles. The first electric mine locomotive built by the Thomson-Houston Electric Co. was constructed in 1899 for the Erie Colliery of the Hillside Coal and Iron Co., and this machine is also still in every-day service.

The figures quoted above show that at the end of 1902 there were 379 electric mine locomotives in the coal mines of Pennsylvania alone. In round numbers, 450 electric mine locomotives were built in the United States during 1902. The production during 1903 was considerably larger.

I have been specially interested in the data furnished by Mr. E. B. Lord, general manager and superintendent of the H. K. Porter Co., of Pittsburg, well-known manufacturers of compressed-air locomotives, comparing the cost of mine haulage with compressed-air and electric locomotives. According to Mr. Lord's figures, the cost per ton with a compressed-air locomotive amounted to $0.01015, while the actual cost with the electric locomotive is stated to be $0.0456, or more than four times as much as with compressed air. Figures of this nature, even when compiled on the ton-mile basis, are inconclusive and misleading, since they do not take into consideration the different conditions in the mines. In a mine where the grades are in favor of the loads, mule haulage would very likely be cheaper than

the most modern mechanical system in another mine, where severe adverse grades prevail; yet it would be ridiculous to argue the superiority of mule haulage on the strength of such a comparison.

Mr. Lord's data regarding the cost of compressed-air haulage are taken from an able and interesting paper by Mr. J. H. Bowden, formerly chief engineer of the Susquehanna Coal Co., and apply to the No. 6 Colliery at Glen Lyon, Pa. The costs of electric haulage were prepared by Mr. W. A. May, general manager of the Hillside Coal and Iron Co., and pertain to the No. 2 Shaft at Forest City, Pa. Under date of July 1, 1903, Mr. May writes as follows:

"In *Mines and Minerals* for June, 1903, there is an article, entitled 'Compressed Air Against Electricity,' written by W. L. Saunders, in which he compares the cost of compressed air and of electricity, using the cost of haulage at the No. 6 Colliery of the Susquehanna Coal Co. and the cost of electricity at No. 2 Shaft, Forest City, Pa.

"The grade at No. 6 Colliery of the Susquehanna Coal Co., as nearly as I can recollect, is 1 per cent. in favor of the load. At Forest City, the grade runs as high as 4.8 per cent. against the load, two-thirds of the coal being hauled against an average grade of 2.5 per cent. You can readily see from this why the figures seem to be in favor of compressed air. Had the article been prepared in a truly scientific manner, pains would have been taken to make the comparisons under exactly the same conditions and upon the same basis. I think the article ought to be corrected or answered, because it will unfavorably impress people who do not look deeper than the surface."

According to a published description of the compressed-air haulage plant at the Glen Lyon Colliery, "there is an average grade of 1.07 per cent. and a maximum grade of 2.8 per cent. in favor of the load.

A few years ago one of the larger coal-mining companies in the bituminous field installed a compressed-air haulage plant, comprising the following apparatus: One compound-steam, three-stage air compressor, 800 pounds pressure; three 14-ton locomotives; 5,300 feet of 5-inch "triple strength" pipe line, and 3,600 feet of 2-inch "triple strength" pipe line. The cost of this installation, exclusive of the boiler plant, was approximately $37,000. There were two charging stations, and the time consumed by each trip was 45 minutes. The compressor was intended for the operation of all three locomotives; but, in actual service, there was very little margin when one locomotive was in use. Some relief could have been obtained by increasing the speed of the compressor, but for the fact that the boilers were operated at the maximum safe pressure. The cost of the maintenance of the high-pressure plant and the locomotives was respectively $8 and $7.50 per day. This system was employed to haul coal to a long incline upon which the cars were delivered to the tipple by a rope haulage.

An electric haulage system has been installed at this mine, representing an investment of $42,000, exclusive of the boiler plant, and comprising two 150-kilowatt generators, directly connected to two 22 inch by 20 inch simple engines, and six 13-ton electric mine locomotives, beside feeder and trolley lines. One of these locomotives performs all the work of the compressed-air plant, briefly described above, making the round trip in 30 minutes, and is used besides on other headings for two or three hours of the day. That part of the cost of the electric plant properly chargeable, for the purpose of comparison, against the compressed-air haulage previously employed, would be about $7,000. A few months before the original plant was abandoned, one of the compressed-air locomotives was "overhauled" at an expense of $2,000.

The following is an extract from a report regarding this installation:

"We found the item of repairs very high, both on the pipe lines and locomotives. Extremely heavy valves and fittings of all kinds had to be used, which soon became defective, due to the high pressure (800 pounds) and the character of the water and air inside the mine. We found it very difficult to keep gaskets in all the places where used. * * * To use an air locomotive in a seam of less than 6 feet would require that roof be taken down or a locomotive of very small capacity be used. * * * We found the electric locomotive, as applied to our work, much more flexible as well as of much higher efficiency. It was the original intention that this one compressor would take care of three locomotives instead of one, which it might have done had we been able to use steam at 130 pounds and

run the compressor at 140 revolutions per minute, but as it was, this would not work out. We had three locomotives, one of which has long since been scrapped and still have two on hand that will no doubt soon find their way into the scrap heap, as well as the compressor. The design of the compressor is such as to preclude the possibility of using it as an ordinary low-pressure compressor, owing to its very low efficiency."

In my original paper I said that the electric motor seems to be especially adapted for the severe and peculiar conditions which attend the development and distribution of power for the operation of mining machinery. In support of this statement innumerable installations for various classes of service might be described, but a brief reference to a plant installed some years ago in a Colorado coal mine will suffice. According to the report of a test made by Mr. Lewis Searing, of the Denver Engineering Works Co., Denver, Colo., the power plant contained three air compressors, each with 13.5-inch high-pressure and 22-inch low-pressure air cylinders, and a 20-inch steam cylinder with 24-inch stroke, supplied with steam from a battery of two horizontal 60 inches by 16 feet tubular boilers and six plain 36 inches by 36 feet cylinder boilers. The mine pump was duplex double-acting, with 18.5-inch air cylinders, 9.25-inch water cylinders and 12-inch stroke, and connected with the air reservoirs at the power plant through 3,600 feet of 4-inch pipe line. The report says:

"The test of the compressed-air system was made in order to obtain the total efficiency between the steam cylinders of the air compressors and the water discharge of the pump. The amount of water discharged was measured by a weir at the end of the water-discharge pipe on the surface. The weir was 16 inches wide, with a measuring stake 4 feet up stream. A pressure gauge was placed on the water-discharge pipe at the pump and the air pressure was measured at the receiver. Crosby steam-engine indicators were attached to the steam cylinders of the air compressors.

"Observers were stationed at the various points to take readings. Observations were made through the day, commencing at 10 A. M. and ending at 5 P. M. At one time in the afternoon one minute readings were taken for ten minutes. At another time one of the compressors was shut down and the pumping done by two compressors as a check on the indicator measurements.

"The results are somewhat surprising:

Average steam pressure, pounds..	80
Average air pressure, pounds.....	50
Average revolutions per minute:	
Three compressors in operation	64
Two compressors in operation..	110
Average gallons discharged by pump per minute..............	400 (3,320 pounds)
Average strokes of pump per minute	176
Average pressure per square inch pumped against, pounds.... ...	120 (276 feet head)
Average indicated horsepower at steam cylinders and compressors	312

"As the theoretical horse-power required to force 400 gallons per minute against 120 pounds is 28, it follows that the efficiency of the system between the points measured is less than 9 per cent. It will be observed that this is the efficiency of the plant as found under actual working conditions, and includes every loss which may occur between the steam cylinders of the compressors and the water discharge of the pump, and that due to wear of apparatus and to inherent and other defects in the system.

"As there are many mines that are forced to employ a similar method of pumping under similar conditions, it is fair to assume that the above given efficiency is not far from the average, and that nothing short of a change of system would make a material increase in the efficiency. If we go back of the steam cylinders to the coal pile we find a still more deplorable state of affairs, for, to operate these three compressors requires eight boilers, consuming 35 tons of coal per day of 24 hours.

"The probable efficiency of the proposed electric plant was estimated as follows: Direct-coupled generator and engine, 80; line, 90; motor, 85; pump and gearing, 82; total efficiency, 50 per cent.

"With the above efficiency, a 60-horse-power engine would do the work now requiring 312 horse-power by the compressors. Further, assuming the installation of a compound engine, using the mine water for condensing, the total coal consumption per 24 hours would not exceed three tons, making a saving of 32 tons per day."

An electric power plant was subsequently installed, containing a vertical cross-compound condensing engine, 11 and

19 inches by 15-inch stroke, developing 150 horse-power at 250 revolutions per minute, direct connected to a continuous-current 550-volt generator of 105 kilo-watt capacity, and space was provided for additional units of the same description. Generators of this size were selected in order to have sufficient power to operate the ventilating fans, screens and shops about the mines, in addition to the regular mine pumps. The report continues:

"There are two small pumps, used as sinking pumps, which are of the duplex type of the Deane Company's make, driven through gearing by a 15-horse-power motor, mounted on the same frame. The cylinders are 7 inches by 10 inches, and have a capacity of 250 gallons per minute against a head of 115 feet. The pumps are mounted on four-wheel trucks and can be moved around as desired. The station pumps, two in number, are double-acting duplex of the Deane Company's make, with cylinders 9.5 inches by 12 inches geared to 110-horse-power motors. These pumps each have a capacity of 600 gallons per minute, against a head of 400 feet.

"Shortly after the order was given to erect the electric plant an increased flow of water was encountered which flooded the mine, the water coming up the slope 1,500 feet before it was held in check, and an air pump was placed at this point to hold the water until the electric pumps could be put in operation. The water has since been pumped down about 700 feet by the electric pumps, and the work has been as severe a test on the pumps as could be desired. For over a month the two small electric pumps and an air pump have been working side by side in an entry 10 feet wide by 5 feet high, with the exhaust of the air pump (into which a stream of water is discharged to prevent it from freezing) discharging so near the electric pump that it was necessary to protect the latter from the water by an oil-cloth. This is certainly a good test for the waterproof qualities of the motors, which are still doing their work and appear to be in excellent condition.

"The average of numerous tests on the two small electric pumps gives the following results:

Average gallons per minute discharged	500 (4,150 pounds)
Average pressure at pumps, pounds	56 5 (130 feet head)
Average strokes per minute, each pump	172
Average amperes	37
Average station volts	475
Average indicated horsepower at engine	32.86
Average horsepower at pump discharge	16.4
Efficiency:	
Generating unit, engine and dynamo	71.5 per cent.
Motor, pump and line	70 per cent.
Total, from engine cylinder to pump discharge	50 per cent

"As soon as the first station pump was started and in good running order, tests were made, with the following results:

Average gallons per minute discharge	650 (5,395 pounds)
Average pressure at pumps, pounds	64 (147 feet head)
Average strokes per minute	188
Average amperes	53.5
Average station voltage	550
Average indicated horsepower at engine	53.6
Average horsepower at pump discharge	24
Efficiency:	
Generating unit, engine and dynamo	73 per cent.
Motor, pump and line	61 per cent.
Total, from engine cylinder to pump discharge	44.5 per cent.

"Although the total efficiency with the small pumps is as high as predicted it is nevertheless true that the engine and dynamo are working at a disadvantage with a load of but 20 per cent. of their rated capacity. In the case of the large pump, the generating unit is underloaded, as is also the pump, which combine to bring the total efficiency below the estimated 50 per cent. When the mine is finally pumped out and all the pumps and motors are running, the generator and engine will have a comfortable load, and it is safe to say that the total efficiency of the pumping plant will then be very close to 60 per cent.

"The fact remains, however, that at the efficiency above shown by the present working, the former pumping of 400 gallons per minute against 120 pounds pressure, which equals 28 horse-power, can be accomplished by the electric plant with but 56 horse-power at the surface instead of 312 horse-power as before.

"The engine running the generator was supplied with steam from the battery of boilers operating the compressors, but the piping was so arranged that one horizon-

tal tubular boiler, 60 inches by 16 feet, could be cut off from the rest of the battery and supply steam to the electric plant alone. This was not the regular practice, because all the boilers were required to supply the necessary steam, even when two compressors were running, but on several occasions, when the main steam line was shut down for an hour or more, the electric plant was run on the one boiler with ease, the safety valve popping more than once during the run, and this with the engine running non-condensing. Actual results with the compressed-air and electric plants, which are the subject of this report, show that the work of pumping calling for 312 horse-power and eight boilers in the case of compressed air could be done by electricity with but 56 horse-power and one boiler, disregarding even the use of a compound engine and condenser.

"Further, I have no hesitancy in saying that the whole plant of pumps and machinery formerly requiring the eight boilers, taxed to their utmost, can be operated by the present electric plant with but one horizontal tubular boiler."

The objection may be offered that the compressed-air plant described above is out of date, but there are many such plants in operation, and, furthermore, the electric plant would hardly be considered of high efficiency in the light of more recent developments. It follows, therefore, that the above comparison is practically true of modern compressed-air and electric-power plants designed to perform the same duty. Efficiency and economy in the operation of a coal mine, as in other lines of business, are reflected in the balance sheets. The progressive coal operator admits the fallacy of the old argument that "coal costs nothing," and realizes that the coal consumed at the mine should properly be charged at the current market price.

Although my paper dealt only with certain applications of electricity to coal mining, it may not be out of place to mention the extensive and increasing use of electrical machinery in metalliferous mines, especially in the Western States and in Mexico. The difference between a successful and an unprofitable venture has been due in many instances to the employment of cheap power obtained by electric transmission from a distant water-power or coal mine. This is particularly true of "low-grade propositions" involving large tonnages. At one prominent mining plant in Colorado, the cost of hoisting and milling 200 tons of ore per day by steam power was $218. By bringing power from an electric plant at a coal mine 32 miles away, this cost was reduced to $53 for the handling of 300 tons of ore per day. In the old days, the cost of operating the power plants of the famous Comstock Mines in Nevada amounted to $34 per month per indicated horse-power. Electric power is now obtainable at a cost of from $4 to $7 per month per horse-power, depending upon the amount of power consumed, and the resumption of operations in the Comstock Mines, which were shut down for several years, was largely due to the availability of cheaper power.

In Reply.

CLEVELAND, February 18, 1905.

To the Editor of COMPRESSED AIR:

I have read Mr. W. B. Clarke's very interesting paper on "Electricity as Applied in Coal Mines" which appeared some months ago in *Mines and Minerals*. Mr. Clarke goes into an extended analysis and discussion of the relative merits of air and electricity for mine locomotives, pumps, etc., and gives some interesting "exact" figures. His paper is such a convincing exposition of how not to do it that a further study of some of the facts there stated may serve seekers after the truth who may wish to use compressed air with the same good judgment which electricity is usually so fortunate as to enjoy the benefit of.

It is clear that in the tests made where the air pump only showed 9 per cent. total efficiency as against 50 per cent. efficiency for the electric plant, the air plant was not modern and the electric plant was. To be fair, this should have been taken into account.

In the air plant, plain cylinder boilers were used. They were probably old and scaled up and are certainly the least efficient type of boiler known. With the new electric plant we find reference to a modern return tubular boiler, probably new and clean, making the evaporative comparison before the steam gets into the pipe at all, in about the ratio of 5 for air

against 8 for electricity. Mr. Clarke does not mention this.

Next it is plain that the steam cylinders driving the air compressors are simple non-condensing slide valves, while the electric generator is mentioned as being driven by a new Shiny Steeple compound engine with cylinders 11 and 19 by 15 inches happy in having a condenser also to help it out, making the relative steam consumption of the two motive powers compared probably 35 pounds per horse-power hour for the engine driving the air compressor as against, say 17½ pounds for the engine driving the generator, so before we ever get up to the question of air versus electricity generation we have 8 to 5 on the boilers and 2 to 1 on the engines, which isn't the fault of the air either.

Skipping for the moment the generator and compressor in our parallel column, we find it stated that the electric plant is underloaded so the copper line is probably large and the loss in transmission small. On the other hand, the air line is 3,600 feet long and 4 inches in diameter. The working air pressure is given at 50 pounds and the de'Arcy formula, which is generally recognized as standard, says that under these conditions the given amount of compressed air will lose in transmission 15 pounds for each 1,000 feet or the entire 50 pounds before it gets to the pump, so it is probable that there is another mistake here somewhere and that the initial pressure was higher than 50 pounds. At any rate, as a problem in transmission air is again put on a most unfavorable footing as against electricity at its best.

The compressors mentioned are rated by their makers at the speeds given as having a piston displacement capacity of 2,320 cubic feet of free air per minute. Assuming 6,000 feet altitude in "a Colorado mine," this is about 1,880 cubic feet of free air and allowing 90 per cent. volumetric efficiency as being as good as could be expected from the conditions given, we have about 1,700 cubic feet of free air per minute delivered. Now this pump must be in that chronicly bad condition for which the type is so celebrated, as it ought not to take over 1,250 feet of air. This is again 3 to 2 against the air which is here again unfortunate because it will run things and get results when nothing else would under equal conditions, in its good nature allowing itself to be imposed upon.

The compressor horse power is given at 312 when it ought not to have been over 275 according to the data. So take it all the way through there seems to be some room for doubt as to this being as Mr. Clarke assumes, a true parallel with air at its best as against electricity at its best.

Now it also seems that a brand new geared power pump is used with the electric installation, one of the most efficient types for which 82 per cent. efficiency is claimed. Mr. Clarke puts this against an old duplex steam pump which either takes 50 per cent. more air than it should or else the pipe line let it get away from such undesirable conditions.

All this simply illustrates the point made in the beginning that one ought not to take air at its worst and electricity at its best, and then reason out on this insecure foundation to exact conclusions expressed in fine percentages. Here compressed air and electricity are both simply transmitters of power and the question of economy in the generation and use of both are the important points at issue. It is plain that the conditions as to economy were about the best in every way which could be arranged for the brand new electric installation and about the worst which could be imagined for the old compressed air plant. No wonder the air plant showed only 9 per cent. efficiency; the wonder is rather that the electric plant showed so low an efficiency as 50 per cent.

I understand there is to be in this issue a paper elsewhere in which some of the possibilities with compressed air applied to pumping plants along modern lines are pointed out.

If we classify like parts right through on both sides and consider air and electricity simply as power transmitters the absurdity of Mr. Clarke's position is best seen when we cut both air and electricity out. Say we eliminate the wire and piping, cut out the compound engine and the compressor engine as being alike generators of power and let us imagine both pumps moved right up to the boiler. In the one case we find a new efficient geared pump driven direct from a 17½-pound tandem compound condensing engine and in the other an old steam-eating duplex pump with bad proportions, leaky cylinders and enormous clearances using its 250 pounds of steam per horse-power hour, according to the common admission of the makers of such machinery, or fourteen times as much steam as the engine for a given power.

Considering this difference, if the compressor engine and the pump had been on a modern basis taking one-fourteenth the fuel now required, the efficiency would have been away above that claimed for the electric pump. Of course the old pump at its worst will take more steam than a new high duty affair at its best, so the situation is not in any way to the credit of electricity or to the discredit of air. These are simply transmitting the power, and it is up to the pump principally, also to the manner of generation.

Here good engineering is unfairly used to make a strong case for electricity, and the antique air plant at its worst is simply put up as a straw man to be knocked down. Air does not need a defender but preserve us from misrepresentation.

In conclusion, Mr. Clarke remarks that it " follows that this is practically true of modern electric and compressed-air power plants to perform the same duty." In all good nature I beg to doubt it very seriously.

The 2,000 horse-power Ingersoll-Sergeant Central compressed-air power station which I designed and installed at North Amherst, O., has now been in operation for over a full year and a good many ancient fallacies have there been exploded. Among them is the question of freezing in out-of-door work, another the question of economy. The unanswerable, unexplainable, undisputable truth is that this plant is consuming but one-fourth the fuel which was formerly burned for a given duty. There is no denying the economy of compressed air along modern lines in the face of coal burned. Where Mr. Clarke claims 50 per cent. efficiency for electric generation transmission and use, it has been proved beyond all question that, under the same conditions of good engineering and using efficient reheaters, a thoroughly modern central compressed-air power plant is capable of showing an efficiency superior to the best electric plants. There is being operated at this plant a great deal of machinery which formerly required forty-nine boilers aggregating about 2,000 horse power. Now 750-boiler horse power operates it all. There is a 125-horse-power Corliss and an 80-horse-power engine running with air, some dozen or fifteen 50-horse-power hoists, a dozen and a half channeler engines, a lot of pumps, rock drills, powerful grindstone lathe engines, steam hammer, air-lift pumps, shop engines, steam shovel, sawmills and a good many other things, many of which could not possibly be run with electricity and none of which could be operated more economically by electricity. This is a central power distribution plant in the truest sense of the word, reaching three different quarries and several different mills scattered over a large area, and the plant is paying in the neighborhood of 50 per cent. dividends on its complete cost.

The plant is there, open to all who may wish to investigate the facts for themselves and some of the best engineers here and abroad, after looking it over carefully, have said: " It is impossible, but you are doing it." It is up to engineers who may still hold the old fallacies which have been so carefully nursed and believed in by the electric men to get up to date on the air statistics.

I will not attempt a detailed defense of the air locomotive in answer to Mr. Clarke's argument, for it needs none. It is too bad that in criticising an air-haulage plant one should pick out one of the first plants ever installed. If any competent engineer will take the trouble to visit some of the magnificent recent air-haulage plants, some of them of enormous size, he will find that the practical men, who have to get results and who have used both compressed air and electric haulage, will not support Mr. Clarke's point of view.

GEO. R. MURRAY.

Comparison of Electric and Compressed Air Locomotives in American Mines.*

In approaching this subject, it must be borne in mind that there are fashions in machinery as there are fashions in dress, and just now electricity is fashionable in America. To the average man unfamiliar with the facts, electricity appears as something magical; producing results without the expense and trouble incident to old-fashioned means. Careful attention to the statements of generally well-informed men will often develop the fact that it is even conceived as a source of power rather than as a means of transmission.

***A paper by Mr. Beverley S. Randolph, read and discussed before the Institution of Mining Engineers, England, at the general meeting at London, June 2, 1904. Published through the courtesy of the Institution.**

From a careful study of the subject, the writer believes that the advisability of either form of haulage is entirely a question of the conditions which obtain in each case. The pneumatic locomotive is large and cumbersome, and therefore not so well adapted to low seams as the electric locomotive, except where its safety in the presence of fire damp may be held to counterbalance this disadvantage. The delays incident to charging are not so great as would at first appear, since, even in the best-managed establishments, there is more or less lost time at terminals which may be utilized for charging. Again, any unusual amount of work between charging stations, such as may be due to badly lubricated cars or assisting in replacing derailed cars, is liable to exhaust the supply of air in the tanks and necessitate a run to the charging station and back before the train can be brought forward.

On the other hand, electricity has never been successfully applied to the gathering of cars from the rooms or working places, owing to the expense involved in wiring each place and the difficulty in passing round short turns without displacing the trolley. A compressed air locomotive is very successful for this purpose. The small gathering locomotive has the same dimensions as the mine cars in the mine in which it was designed to work, and it can at any time travel on any road traversed by these cars.

The machinery used with compressed air so closely resembles that used with steam that mechanics familiar with the one have little to learn in managing the other. Steam is so generally understood that men competent to manage pneumatic plants are easily obtained, while experts in electricity are scarce.

In the matter of cost Mr. A. de Gennes had stated that the cost of an electric installation was only one-quarter that of a pneumatic plant. This is by no means the first time that this statement had been made, and its vitality in the face of easily ascertained facts was an interesting psychological phenomenon.

As a matter of fact, the electric plant is usually the more expensive, and we have not far to go to discover the reason. In the construction of the locomotive the same weight of metal must of necessity be used, and as there is little difference in the labor involved the cost is practically the same.

Comparing the pipe and the transmission wire, the latter is cheaper for short distances, but, as its cost increases as the square of the distance, while the cost of the pipe increases directly as the distance, a point is soon reached where the cost is equal; and, beyond this, the difference grows rapidly against the electric plant. In fact, one prominent establishment in the State of Pennsylvania is reported to have reached a point beyond which the cost of the conductors becomes so great that it will be necessary to remodel the entire plant on a basis of higher voltage. It is the usual practice in pneumatic plants to adjust the diameter of the pipe with a view to its storage capacity rather than simple transmission, in order that the locomotives may be charged promptly at a pressure near the normal, and consequently additions can be often made with a smaller size of pipe.

The greatest difference of cost is found in the generation of the power. In the electric plant this feature must be sufficient to meet the greatest demand that can be brought upon it at any one time, although the remainder of the run may require only a small part of this maximum demand. Not only does this involve a large first cost, but no such plant can be operated economically if it runs the greater part of its time much below its capacity, especially when it must be kept in constant readiness to respond to this maximum demand at any time without notice. In the pneumatic system the elasticity of the air provides for this excessive demand and distributes the work over a considerable time. This not only admits of the installation of a smaller plant, but it allows of its adjustment to an even rate of energy production, which is very conducive to economy of operation. Consequently, the electric plant must be proportioned solely to meet the maximum demand, while the pneumatic plant is proportioned to meet the average demand; and it is not difficult to imagine a case where this average demand will be only a small fraction of the maximum demand.

These disadvantages appear to balance the somewhat lower efficiency of the pneumatic system, due to the loss of heat in compression, so that there is little difference in the cost of operation.

During the past year the writer had an

opportunity of comparing the actual cost of plants in successful operation, the maximum haul in each case being about 8,000 feet.

A. Compressed air plant operating two main hauling locomotives, each weighing 30,000 pounds, and five gathering locomotives, each weighing 8,000 pounds, a total weight of 100,000 pounds. The cost was as follows:

A three-stage air compressor and a compound steam engine	$5.300	£1,104
5,600 feet of pipes, 5 inches in diameter	5,600	1,167
3,100 feet of pipes, 2½ inches in diameter	1,700	354
1,000 feet of pipes, 1½ inches in diameter	300	63
Two locomotives, each weighing 30,000 pounds	6,000	1,250
Five locomotives, each weighing 8,000 pounds	10,000	2,083
Two boilers, each of 80 horsepower	1,000	208
Installation	4,000	833
Totals	$33,900	£7,062

B. Electric plant of four locomotives, each weighing 26,000 pounds, a total weight of 104,000 pounds. The cost was as follows:

Generator, producing 225 kilowatts	$3,900	£812
Engine, 500 horsepower	4,800	1,000
Boilers, 600 horsepower	4,400	917
Foundations, piping, etc	1,500	312
Wiring	8,000	1,667
Four locomotives, each weighing 26,000 pounds	9,500	1,979
Totals	$32,100	£6,687

C. Electric plant, comprising two locomotives, each weighing 26,000 pounds, a total weight of 52,000 pounds. The cost was as follows:

Generators, etc	$24,000	£5,000

The A plant was installed and is being operated under the direction of the writer. The costs for the B and C plants were supplied by the superintendent now in charge of their operation; the B plant was installed under his direction, and the C plant by his predecessor. There is no reason to suppose that these values are to any extent misleading, and as the gentleman is a pronounced electrical enthusiast, they are certainly not exaggerated.

The draft of a locomotive is a function of its weight, and it forms a convenient unit for comparison. The costs of the three plants per 1,000 pounds of locomotive operated, on this basis, are as follows: A, compressed air, £70.62, or $339; B. electric, £64.29, or $309; and C, electric, £96.15, or $461.

The B plant possesses an advantage in this comparison, due to the fact that it works against a gradient in hauling outbye only, and when hauling inbye all the gradients are descending. There are two parallel roads, and two locomotives are going inbye and two are coming outbye all the time, and the generator is never loaded with more than two locomotives. If worked on undulating gradients, as in the case of the other two plants, where all the locomotives might be on maximum gradients at the same time, it could not be relied on to drive more than three locomotives, with a total weight of 78,000 pounds. The plant, with three locomotives, would have cost £6,192, or $29,725.

An inspection of the cost given above for the A plant will show that its locomotives cost much more than those of the other two, but this is largely due to the number of small gathering units. If this plant had been equipped with four locomotives, each weighing 25,000 pounds, they would not have cost more than £583¼, or $2,800 each (or £2,333, or $11,200 for the total weight of 100,000 pounds). The plant would then have cost £6,062, or $29,100.

Amending the calculations on the basis of these revised locomotive weights, the costs of the three plants per 1,000 pounds of locomotives operated are as follows: A, compressed air, £60.62, or $291; B, electric, £79.38, or $381; and C, electric, £96.15, or $461.

Upon the question of cost of repairs, there is a considerable difference of statement and opinion. This is doubtless due to the fact that this item is always largely influenced by the *personnel* of the operating force. A few years ago the balance was largely against the electric system, but owing to later improvements, the fruits of earlier experience, the advantage is now probably with this system.

The prices given for various items in this paper are based on market conditions obtaining several years ago, when these plants were installed, and they will probably be found to be 10 to 15 per cent. higher than present day prices.

Mr. SYDNEY F. WALKER (London) said that he would not be suspected of undue leaning against electricity, but he thought that it would be better if compressed air engineers would tackle the work properly, in the same way as electrical engineers had tackled theirs, and they would then

make a better show than they did. One thing essential was for them to use higher pressures, and if they did so compressed air would then be able to make a much better show with regard to running costs. If air were used at higher pressures, although more heat would be generated per pound of air, a pound of air would do more work. The two powers, electricity and compressed air, ran on parallel lines. When air was compressed heat was generated, and the same thing occurred in electricity; and the best thing that could be done in both cases was to remove this heat as soon as generated. Electricity had a great advantage over compressed air in the matter of transmission. No attempt at present, so far as he knew, had been made to use the air expansively. One part of the problem to be solved was the avoidance of the enormous leakage that accompanied the use of air at high pressures. In America one heard of pressures of 1,000 pounds per square inch being transmitted inbye, and if this could be done in America it ought to be accomplished in Great Britain and elsewhere. Mr. Randolph stated that electric locomotives had never been used for gathering tubs, as there was a difficulty in getting the trolley to go round the corners; but he (Mr. Walker) thought that one hardly needed to be reminded that when electric tramcars in streets were first introduced there had been the same difficulty and it had been overcome. It was quite correct to say that the cost of the electrical transmission line varied as the square of the distance; but this was only true if the loss in the transmission line was kept within the same limits. In the case of compressed air the same thing occurred, and to keep down the loss the size of the pipe must be increased. The costs given by the author were misleading, and he (Mr. Walker) might point out that the load factor which he claimed for a compressed air plant applied very largely to an electric plant. Where a number of locomotives or coal-cutting machines were at work, there was always a certain number only at work at one time; and, therefore, if any one wanted to cut matters fine, they could easily do so by erecting a plant capable of supplying the mean demand only. Mr. Randolph also said that an electric plant would not run economically unless it were run at the maximum load. Of course, any plant ran more economically and efficiently with the least charge for conversion, when it was doing all the work that it could; but one of the features of electricity was that the efficiency did not fall as the load decreased in the same proportion as it did in the case of other power plants, so that the electrical plant had the advantage under such conditions. The electrical plant mentioned by Mr. Randolph was evidently erected as an experimental one some years ago, and was not put in so economically as it would have been at the present time. It was, therefore, hardly fair to judge the two plants in the way that he had done. He (Mr. Walker) thought that if the whole question was gone into where electric locomotives were used—although unfortunately there were not many coal mines in the United Kingdom where they could be used—where they could be employed safely and where sparking at the trolley did not matter—it would be found that electric locomotives were more economical in first cost and in running cost than compressed air locomotives.

Mr. Henry Hall (H. M. Inspector of Mines), said that he was glad to hear from Mr. Walker that there appeared to be a future for compressed air. Electricity was a profession, and had some very clever men at the back of it, but no engineer in particular had taken up compressed air, and it had, therefore, to fight its own battle, whilst electricity had been backed tooth and nail by very able people. From the point of view of safety, compressed air had a great advantage over electricity; the members had only to read the proposed Special Rules to realize the dangers resulting from the use of electricity.

Mr. C. C. Leach said that it seemed hardly possible to keep a compressed air plant at the same state of efficiency as an electrical plant.

The Rev. G. M. Capell (Passenham) said that the electric locomotives in use at the Marles colliery, Pas-de-Calais, were small, about 7 feet long, and they ran on a narrow gauge below ground. They hauled a load of about 15 tons each and were managed generally by a small boy. The same kind of locomotive was in use at the Grand Hornu colliery in Belgium for conveying coal above ground from the various centres to the cleaning plant, and the boys in charge, generally about thirteen or fourteen years of age, worked

the locomotives with the greatest ease and intelligence. He suggested that electricity might be used to work an air compressor below ground at a distance inbye, and thus drive on compressed air for use in the gassy and dangerous portions of the mines.

Mr. Roslyn Holiday said that he had taken tenders for a plant to work coal cutters, one driven by electricity and one by compressed air, and he had found that a combined plant to run two coal cutters could be obtained for the same money as would run four coal cutters in the ordinary way.

Mr. H. Richardson Hewitt (H. M. Inspector of Mines) wrote that he quite agreed with Mr. Randolph that the conditions appertaining to each case must control the type of locomotive to be used, and further, that electric locomotives would be prohibited in fiery mines. If electric locomotives were ever used in this country, it would be necessary to provide a separate traveling road for men and horses, owing to the proximity of the trolley wires carrying the current; and he presumed that the driver was protected by the covering of his cab, or was placed in such a position that he was clear of the trolley wires. Mr. Randolph gave examples of power generation, and it would be interesting if he would give the tonnage drawn by each plant described, the distance traveled by the locomotives of each type, and the average cost of upkeep.

Mr. A. S. E. Ackermann (London) asked Mr. Randolph to explain why the cost of copper conductors increased as the square of the distance, while the cost of piping for compressed air was only directly as the distance. It was also astonishing to find that the estimate for the air power plant was for only 160 horse-power, while that for the electric plant was for 600 horse-power; such disproportion certainly needed some further explanation. No mention had been made of the very much greater rapidity with which electric conductors could be fixed than lines of pipe, nor of the fact that the fixing was simpler and cheaper. There was also no corrosion in the case of the copper mains, whereas, in some mines, the water was particularly corrosive and caused considerable damage to the air mains. He could not help thinking that the vibration caused by the want of balance of pneumatic locomotives would cause considerably more wear and tear of the track than electric locomotives. With regard to the difficulty of the maximum demand in the case of an electric installation, it was quite possible to use a storage battery, which would permit of a considerably smaller electric generating plant, much in the same way as air storage vessels permit of a smaller air compressing plant being used than would otherwise be necessary.

Mr. Henry Davis (Derby) wrote that it would be instructive to be able to compare the weights, effective horse-power or draw-bar pull, etc., of the electric and compressed air locomotives referred to by Mr. Beverley S. Randolph, particularly of the gathering locomotive weighing 8,000 pounds, and to see whether this would compare in draw-bar pull with the electric locomotives made by the Jeffrey Manufacturing Company of a similar weight. So far as one could gather from Mr. Randolph's paper the comparative figures were as follows:

Description.	Weight of Locomotive.	Draw-bar Pull.	Speed per Hour.	Minimum Gauge.	Width over all, with Minimum Gauge.	Height over all, excluding the Trolley.	Length over all, excluding the Buffers.
	Pounds.	Pounds.	Miles.	Inches.	Inches.	Inches.	Inches.
Air-power locomotive......	8,000	Not	stated.	Not stated.	46	61	120
Jeffrey electric locomotive.	8,000	1,000	6 to 10	36	55	39	98

The cost of the two engines would probably approximate one to the other, but Mr. Randolph would not wish to give the impression that air power could be conveyed any considerable distance with the same efficiency as electric power. It would also be interesting to hear whether

Mr. Randolph could state whether the prominent establishment in the State of Pennsylvania to which he referred had discontinued the use of electrical engines in favor of air power, or whether, as would appear, a higher pressure for the electric transmission had been adopted.

Mr. J. F. Lee (Glapwell Colliery, Chesterfield) wrote that it would interest the members and be of value to them if Mr. Randolph would give the cost per horsepower for transmission of compressed air and electric power in the plants that he described in his paper. There were various opinions as to whether the first cost or capital outlay for an air compressor or an electric installation was the highest; but he thought that a matter of more importance was the cost of transmission after the plant had been installed. Whether the power was used for locomotives, rope haulage, coal cutting, pumping or any other underground work required to be done, after the question of safety had been considered, the chief point was to adopt the power that would give the greatest efficiency, and consequently the least cost of transmission. The dangers of electric power for underground work had been greatly reduced by the introduction of induction motors, with switches, fuses, and all parts where sparking was likely to occur properly covered by suitable oil or carefully protected in some other way; and with cables laid in a groove in the floor of the mine, in clay or other substance, so as to protect them from water and corrosion, the danger from falls of roof and damage by haulage trains would be entirely obviated. With a sensitive governor attached to the steam engine generating the electric power, the current required could be easily adapted to the work in the same way as the elasticity controlled the supply of compressed air. From his (Mr. Lee's) observations there was no doubt that the cost of electrical transmission was very much less than that of compressed air power in the ordinary way as used in British mines. He (Mr. Lee) had made trials of the efficiency at a single-stage ordinary water-jacketed air compressor, with the outside of the cylinders kept cool by water circulation. Indicator diagrams were taken simultaneously at both the air compressor and the engines doing the work underground. The temperature of the compressed air was taken as it left the compressor and also just before it passed the throttle valve at the motor, so as to note the loss due to fall in temperature, and pressure gauge readings were taken at the same points to ascertain the loss due to friction in the pipes. The following results were obtained: Loss by the fall in temperature, 54.85 per cent.; loss due to friction, as shown by the loss of pressure, 5.42 per cent.; loss not accounted for, but which may be ascribed to piston and valve clearance, leakages, etc., 27.04 per cent.; leaving an efficiency at the engine, in actual work, of only 12.69 per cent.

This compressed air plant had recently been replaced by an electric installation, and although he had not, up to the present time, been able to obtain the losses in detail for electric power transmission, he had been able to satisfy himself that the cost of the latter was very much less. The electric plant was doing the work of the air compressor, together with considerable additional hauling and pumping; and further, the pumping as well as the hauling had all been done during the day, thus knocking off entirely the working of the power plant at night.

Mr. Henry Lawrence (Newcastle-upon-Tyne) wrote that locomotives worked by compressed air were introduced into the mines of the Earl of Durham by Messrs. W. Lishman and W. Young about 1885, and one was exhibited by the Grange Iron Company in the hauling ground of the Newcastle Exhibition in 1887, and formed part of the exhibits of several systems of underground haulage. The compressed air, formed in three stages by a vertical engine on the site, was delivered directly into the receiver or boiler of the engine, at a pressure of 400 to 600 pounds per square inch. To prevent the attendant applying too great a pressure, more than was necessary for the ordinary working of the load, a reducing valve was introduced limiting the maximum pressure necessary for working the load. There was no difficulty in working the engines underground, except that they required better roads and heavier rails than were generally used. The air pipes carried the air into the workings, and the refilling of the receivers was very simply effected and occupied about one minute.

The engines illustrated in Mr. Randolph's paper could not be applied in Great Britain, on account of their great

weight, length and height, unless suitable working places, curves and rails were prepared for their use. These changes might easily be incurred in opening out a new mine, but the greatest drawback to their use in this country was the production of sparks when the wheels of the engine skidded at various gradients and at starting.

This sparking prevented the use of compressed air locomotives in South Wales, and added to the danger from sparks was the upheaval of the floor of the mine, displacing the rails that formed the way, etc. Experiments were made by the writer (Mr. Lawrence) and others during two nights in one of the mines in South Wales, and during the time occupied in running inbye, about 1½ miles, the roads were all right; but on the return journey the rails were shifted in several places, and had to be re-adjusted before the locomotive could pass. Further experiments were tried as to the danger of sparks, and it was proved that they would ignite gas.

Although it appeared from Mr. Randolph's paper that a compressed air plant was more expensive than an electric plant, on account of the loss of heat by compression, he (Mr. Lawrence) preferred the use of compressed air locomotives to those worked by electricity, because compressed air in mines, especially deep ones, was of service by the exhaust air aiding the ventilation, and there being no necessity for the use of return pipes; while in an electrical plant a return cable would be required, and there would be a great danger of the cables being displaced by falls from the roof, etc.

The compressed air engines, as worked in mines in Durham, were small, those used by the putters in collecting the tubs to the main roads weighing only 1,350 to 1,575 pounds each, and the larger ones not more than 4,500 pounds each, against the 8,000 and 30,000 pound locomotives illustrated in Mr. Randolph's paper.

In conclusion, he (Mr. Lawrence) might mention that, some years ago, some small compressed air locomotives were made for use in tunneling abroad, and to save piping the air into the tunnel a series of tenders were made, containing as much compressed air as would work for a length of 1 mile, and an easy method of coupling to the engine one or more of these tenders was applied.

The CHAIRMAN (Mr. H. C. Peake), in moving a vote of thanks to Mr. Randolph for his paper, said that he was rather surprised at the costs given for electricity. The writer had stated that for a short distance electricity would be cheaper, but as the distance increased the cost would increase so greatly that compressed air would be the cheapest in the end. He (Mr. Peake), however, thought that the increase of cost in both would be in the same ratio. In the case of compressed air larger pipes would have to be used, and for electricity larger conductors would have to be employed, to convey the power from the point where it was produced to the point where it was used. He agreed with Mr. Walker that compressed air would have come more to the front had it not been for electricity, which had taken the lead because it could be more easily conveyed to any distance where it was wanted. He asked the author to supply the cost of working the locomotives, the quantity of the loads and the distance they were hauled.

The Rev. G. M. CAPELL seconded the resolution, which was cordially approved.

Electric and Compressed Air Locomotives in American Mines.

A paper on the above subject was read at the meeting of the Institution of Mining Engineers, held in London on June 2, and gave rise to an interesting discussion. The author (Mr. Beverley S. Randolph), at the recent meeting in Birmingham submitted his reply to the points raised by the various speakers. In reply to Mr. S. F. Walker, the author disclaimed the title of "compressed-air" engineer. Two of the collieries under his charge happened to be situated where compressed air promised the best results, and had been equipped with duplicate plants. In the largest and most economically operated colliery the main haulage is accomplished with ropes and the gathering with animals. His reason for presenting the subject before the members of the institution was that he considered it unfortunate that the present rage for things electrical should be allowed to obscure a method of mine haulage possessing so many advantages as compressed air under proper conditions.

With regard to the age of the electric

plants mentioned in his paper, Plant C was an old one, but Plant B was installed in 1902, and was in every respect up to date. The rapid increase in the cost of transmission wires, with the increase of length, which some of the members appeared to question, was readily explained. The resistance to the passage of an electric current was directly as the length and inversely as the section, or, which was the same thing, the weight of the conductor. To maintain a constant resistance, therefore, the weight of a unit in length of the wire must be increased as the distance transmitted was increased. Since the number of such units necessarily increase in proportion to the length, they had the item of length entering twice as a factor in any expression for total weight. Consequently, the total weight would vary as the square of this factor. To express it algebraically, let w represent the weight of a unit of length of any conductor opposing the desired resistance, then wl would represent the weight of the same unit for a distance l. The expression for the total weight of the conductor would be $w\,l^2$.

An examination of the items given in the compressed air Plant A would show that after the first 56,000 feet of 5-inch diameter pipe was installed the additions were made with smaller sizes. The ratio of cost to length was therefore decreasing, instead of increasing, as in the case of electricity. The large size pipe was not needed for transmission, but was a cheaper form of storage than short tanks would be, and was introduced for that purpose. The longer the distance the more prominent this feature of the compressed air plant became. The difference in boiler power to which Mr. Ackermann had directed attention illustrated another advantage which was frequently present in compressed air plants, and which did not appear to have been made sufficiently plain in his (Mr. Randolph's) paper.

Plant B, as stated, was not proportioned to drive all the locomotives at once. The conditions prevailing were such that there was scarcely a possibility of this being needed. Three was the greatest number which were likely to be using current at once. These three weighed 78,000 pounds. If 20 per cent. were allowed for draw-bar pull, they would have 1,566 pounds, which, at 700 feet per minute, would develop 10,920,000 foot-pounds, or 333 horse-power. This, it would be noted, was 55 per cent. of the 600 horse power at which the boilers were rated, and, while special trials might show better results, it was excellent practice to deliver 55 per cent. of the rated boiler power at the draw-bar. Were it desired to operate all four locomotives simultaneously at this maximum, greater boiler power would be needed.

In Plant A the stated boiler power was operating the plant satisfactorily. The electricity of the air so distributed the energy that the average only was called for, without regard to what the locomotives may be using at any given instant. The total weight of the locomotives in this plant was 100,000 pounds. It was quite possible for them all to be exerting their maximum draught simultaneously, which at a velocity of 700 feet per minute would develop 424 horse-power, while the average demand for the day might not exceed 75 horse-power.

In reply to Mr. Davis' request for the draw-bar pull, it might be stated that in any locomotive which depends on friction for its adhesion this was a function of its weight, and was independent of the character of the power by which the machine was actuated. In reply to Mr. Lee, regarding the cost of transmission per horse-power, there were no such figures in existence for the plants in question which had any value. The difficulty in obtaining them consisted in the practical impossibility of measuring the energy delivered by the locomotives with sufficient accuracy to make the results of any value. Attention might be called to the fact that this feature only affected the amount of fuel consumed, which was usually less than 15 per cent. of the total cost of operating a haulage plant. A short test with a regular consumption of power would probably show to the advantage of electricity, while a day's run with heavy fluctuations of demand would undoubtedly show to the advantage of compressed air. It was true that the consumption of steam could be very closely adjusted to the needs by methods now in use, but this was not the case with the fuel consumed. Something could be done by regulating the draught, but not enough to prevent large losses where the fluctuation in demand was excessive.

In reply to Mr. H. C. Peake, the cost of operating these plants was as under. In this comparison there was a difficulty

with Plant A, owing to the fact that 40 per cent. of the weight of the locomotives was used for gathering. At times they were fully loaded, at others were hauling only 1 per cent., or passing from room to room without any load, to say nothing of switching. It would, therefore, be misleading to compare their results with those of locomotives running continuously with full loads. In this comparison, therefore, 40 per cent. of such costs as were common to both classes are charged off to these lighter machines, leaving 60 per cent. to be charged to the larger machines, which haul on the main roads and operate under conditions similar to those of the electric plants.

PLANT A (COMPRESSED AIR)—GENERAL DAILY EXPENSES.

	s.	d.
Coal, 4 tons, at 4s.	16	0
Fireman	9	2
Mechanic at compressor	8	9
Interest and depreciation	40	0
	73	11

The expenses of operating the main haulage locomotives would then be as under:

	s.	d.
Two motormen, at 9s.	18	0
Two brakemen, at 8s. 6d.	17	0
General expenses	44	6
Repairs and oil	12	0
	91	6

These machines haul 160 tons per hour, or 1,600 tons per day of ten hours, an average distance of 6,140 feet. The cost per ton moved per 1,000 feet would therefore be:

$$\frac{22.90}{1,600 \times 6,140} = 0.00233$$

PLANT B (ELECTRIC)—GENERAL DAILY EXPENSES.

	s.	d.
Four motormen, at 9s.	36	0
Four brakemen, at 8s. 6d.	34	0
Fireman	9	2
Mechanic at generator	8	9
Oil, etc.	2	8
Interest and depreciation	44	0
Repairs	4	0
6.25 tons coal, at 4s. per ton	25	0
	163	7

This plant hauled 1,560 tons of coal per day over an average distance of 8,825 feet. The cost per ton moved 1,000 feet would therefore be:

$$\frac{41.02}{1,560 \times 8,825} = 0.00298$$

The excessive cost here is due to a long, heavy grade against the loads.

PLANT C (ELECTRIC)—GENERAL DAILY EXPENSES.

	s.	d.
Four motormen, at 9s.	18	0
Two brakemen, at 8s. 6d.	17	0
Repairs and oil	4	0
Fireman	9	2
Mechanic at generator	8	9
Oil and grease	2	0
Coal	16	0
Repairs, etc.	2	0
Interest and depreciation	32	0
	108	11

During the month of April, 1904, this plant delivered coal at the rate of 152 tons per hour, or 1,520 tons per day of ten hours. The cost per ton moved would therefore be:

$$\frac{27.30}{1,560 \times 8,000} = 0.00225$$

The conditions here are much the same as with Plant A, though the longer haul gives a slight advantage to the electric plant in this comparison, in that there is less total time lost in coupling and starting during the course of the day. When this and the number of estimated factors which necessarily enter are considered, the results of A and C may be considered identical.—*The Colliery Guardian* (Eng.).

Pneumatic Haulage by Compressed Air Locomotives in Mines.*

Pneumatic haulage is to some extent employed in the following systems of hauling: By hand, by animals, by chain or cable, by steam and by electricity. These different systems the author describes, comparing them with one another, and examining their advantages and disadvantages. As a result of his comparison the different advantages and disad-

*Abstract of a paper by A. de Geunes in Transactions of the Society of Civil Engineers, France, as published in the *Mining Reporter*.

vantages of pneumatic haulage are set forth. The principal of these—which in the original paper are explained in detail —are as follows:

1. Safety. As Mr. Saunders remarked before the American Institute of Mining Engineers, air is what is necessary in a mine and not electricity. The former is safe and reliable, the latter dangerous and destructive.

2. Facility. Electric locomotives can scarcely ever leave the main track whilst pneumatic locomotives go, at least in the United States, on the sidetracks and bring back the coal to the main line.

3. The cost of installation and of management and the cost price are not so high with pneumatic traction. The economy of electricity is more in theory than in practice as the apparatus are not strong in construction, require to be constantly looked after by a trained attendant, repairs are frequent and costly, and, finally, the losses owing to the bad insulation of the wires, small at first, become rapidly very great in a mine always more or less damp. Compressed air, on the other hand, necessitates but simple, strong apparatus, the only kind which are suitable in a mine. And if it is true that its theoretical efficiency, especially with high pressures, is not great (20 to 30 per cent.), it offers, on the other hand, the advantage that there are only used machines, which require but little care and the repairing of which are so simple that they can be performed in any workshop.

Mr. de Geunes made a comparison between the mechanical efficiency of the different apparatus employed in a mine and what he calls the industrial efficiency, which includes, not only the mechanical efficiency, but also all the modifications which local conditions might bring about.

Mr. de Geunes then examines the two principal tools which have recently made great progress and which have allowed of the large utilization of pneumatic haulage in the United States; he describes a high pressure air compressor (88 kg.), then the pneumatic locomotive, of which he gives several views and gives examples of operation in United States mines in which he compares pneumatic haulage on the one hand and animal and electric haulage on the other.

Following are some details regarding the pneumatic locomotives in operation at the Aragon mine of the Olivier Iron Mining Company, Norway, Michigan. They have one or two large high pressure air tanks and a small auxiliary tank at low pressure. This latter draws compressed air from the first tank or tanks, at a uniform pressure, through the intermediary of the automatic valve pressure regulator situated between them. It then distributes this air to the cylinders of the locomotive, the other devices of which scarcely present any difference from those of a steam locomotive, and possesses its strength and simplicity without presenting its dangers and expenses. The pressure of the principal tank varies from 28 to 63 kg., according to the work to be done. Generally this tank is formed of a sheet of cast steel rolled and rivetted; sometimes, however, weldless steel tubes are employed with pressures reaching to 105 and 175 kg.

The author concludes his paper in expressing the opinion that mechanical haulage seems to be exactly what is necessary for French coal mines of large extent and in which there exists danger from fire damp.

Compressed Air in Mines.

To explain why ice clogs the exhaust pipes of motors (pumps, air-winches, rock-drills, etc.), driven by compressed air, it is necessary to begin at the compressor, and thence follow the air in its course to the motors.

I shall not go into detail concerning the heating of the air whilst being compressed, as a knowledge of its subsequent behavior will be sufficient to understand the above phenomenon.

The air after leaving the cylinder of the compressor and passing through the receiver may yet have a greater temperature than the atmosphere of the mine; and as it descends through the pipes it becomes cooler, and therefore cannot hold its original quantity of moisture in suspension.

The water after being deposited is carried along with the air to the pumps, etc., and if the mine atmosphere is very dry part of the water quickly evaporates as it leaves the exhaust.

To cause evaporation heat is required, and it is extracted from surrounding objects—in this case chiefly from the motors —which are thereby reduced in tempera-

ture to the freezing point. The unevaporated water consequently congeals and the exhaust pipes become clogged with ice.

The principle of vaporization may be forcibly illustrated by placing a few drops of ether on the back of the hand, which will quickly become almost frozen into insensibility by the rapidity with which the ether evaporates, and the consequent loss of heat.

The wet bulb of a hygrometer is also an example of the same principle.

For small pumps and winches I have found that a large oil lamp placed under the air-chest gave out sufficient heat to keep the moisture from freezing.

Large motors are usually supplied with hot air—the heating furnace being placed as near as possible to the motor.

I do not consider the above to be the correct way to remedy the evil—although re-heating greatly adds to the efficiency of the air as a motive power—and the above methods can only be applied in metalliferous mines or other places where explosive gases are not likely to exist.

The correct remedy consists in cooling the air as much as possible while being compressed. It may be further cooled in a receiver, and the water of condensation drained off. The receiver usually consists of a cylindrical iron or steel tank of large dimensions—not necessarily for storage, but to offer as large a cooling surface as possible to the heated air.

By the above means the desired effect is obtained *only in winter*. In summertime (almost all the year round in this country—the Transvaal) the receiver is the greatest *cause* of the above-mentioned evil.

On most mines the receivers are placed in the open air, under the direct rays of the sun, and are usually colored black to further add to the heat-absorbing power of the metal.

In making some tests on one mine—and it is typical of the others—I found the underground temperature to be 65 degrees F., and in the vicinity of the receiver the thermometer registered 110 degrees F.

Is it any wonder that the pipes in the mine always contain a large quantity of water, and that pumps and other air-motors "freeze" when the air is reduced 45 degrees in temperature in its journey from the receiver to the motors?

The want of attention to this branch of engineering is scarcely consistent with the up-to-date methods for which the Rand is noted.

Freezing is not the only evil which results from an abnormal quantity of water passing to the motors. The oil is washed away in a few minutes, and the working parts are thereby devoid of a lubricant.

I have seen slide (and other) valves which were worn out in a comparatively short time owing to this cause. In this—Krugersdorp—district alone, where there are so many pumps, rock-drills, etc., the cost in repairs and for *wasted* oil must amount to a considerable sum.

A receiver is highly desirable to assist in cooling the air after leaving the compressor and to collect the water precipitated from the air; but to effect this it must be covered with some material which is a non-conductor of heat, or otherwise enclosed from the rays of the sun. At most mines the receiver could be covered up in some of the numerous "waste pumps"; or where the reservoirs or dams are situated on rising ground it could be immersed in the water.

This would only be practicable where the water from the receiver could be conducted—through a drain pipe along the bottom and through the foundation of the dam—to lower ground.

An automatic valve (a modification of the steam trap) ought to take the place of the plug cock which is usually attached to the drain pipe.—WILLIAM LACEY, in *The Science and Art of Mining*.

The Christensen Air Brake.

Though this brake is now so widely used throughout this country being applied to 90 per cent. of all the roads that are equipped with independent motor-driven compressors, the general details of the construction are not so well known and it is proposed therefore to deal with them here.

The system in use in ordinary street railway service, where not more than one or two trailers are ever drawn, is known as the straight-air system, such a system being more satisfactory for this purpose than the automatic air, the latter being more suitable where trains of at least three cars are coupled together.

In its most elementary form the straight air brake may be described as comprised

of an electric motor-driven air compressor which stores compressed air at a pressure of 60 to 80 pounds per square inch in a suitable reservoir. From this reservoir, by aid of a special form of three-way cock, the motorman can admit air to, or allow air to escape from, a brake cylinder under the car, which is connected by suitable levers to the brake shoes of the car trucks.

The motor-driven compressor is a very compact piece of apparatus, consisting of a series-wound direct-current motor mounted directly above a duplex single-acting compressor which it drives through a pinion and gear. The connecting rods are operated by a steel crank shaft with the cranks set at such an angle as to give the best balance to the moving parts. This shaft is extended at one end to receive the gear wheel which meshes with the pinion of the armature shaft directly above. A herring-bone, or as it is otherwise called, a double helical machine cut-gear is used which insures smooth and silent running.

The suction and discharge valves are made of seamless cold-drawn steel with closed tops and are all the same size so that they are interchangeable before grinding in. Their dimensions are such that a small lift only is required and the clearance space reduced to a minimum. They are operated by compressed air and reseated by gravity, no springs being used. They are conveniently arranged in the back cylinder head so that each is independent of the other and separately accessible. The pistons are of the plunger type and provided with a three-part piston ring specially designed for air-compressor work. Compressed air is admitted under the rings by means of three small holes connecting with the interior of the cylinder. Since a machine of this type will get very little attention, special care has been devoted to the lubrication—splash lubrication is adopted—the crank chamber being partly filled with oil in which the connecting rod ends can splash and thus cause all the parts to be automatically and continuously lubricated, including the air chambers. The crank chamber is connected with the gear case space by a passage so that oil may be at the same level

CHRISTENSEN MOTOR-DRIVEN AIR COMPRESSOR.

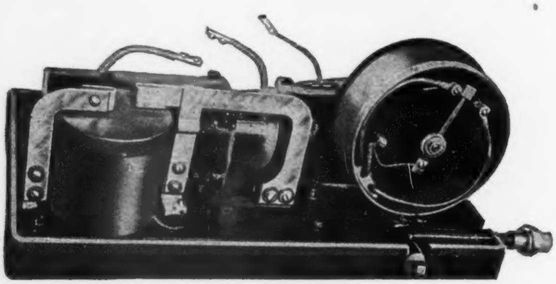
in each. An elbow is provided at one side of the compressor for refilling purposes, and it is set in such a position that when the oil is kept up to its level there will be sufficient oil in the compressor base for efficient lubrication. To prevent the oil spilling this elbow is fitted with a suitable closing plug and handle. The armature bearings are of the self-oiling type provided with revolving rings which carry a continuous supply of oil from a reservoir of ample capacity beneath each bearing; in addition the armature bearing at the gear end is supplied with a continuous stream of oil carried up by the gear wheel.

The motor is of the four-pole type, having windings on two poles. It is series-wound and specially designed to withstand the severe conditions met with in driving an air compressor, and so arranged that it will not require a starting resistance. Two brush-holders only are used, which are conveniently placed on the upper side of the commutator.

Special attention has been paid in the manufacture to make every part easily and quickly accessible, as well as interchangeable. The field frame of the motor is made in two parts so that the armature and field coils may easily be reached, and the general arrangement is such that the gear, pinion, valves, cylinder heads and complete motor may be individually moved without disturbing other parts in a minimum time.

Since the air cylinders are not water-jacketed the compressor cannot be run continuously; a suitable ratio of running time to stopping is one in three. To start and stop the motor compressor at the desired minimum and maximum pressures an electrically operated governor is used. This apparatus consists of a special switch in the motor circuit operated by a plunger which is controlled by two solenoid magnets, which in their turn are operated by a Bourdon pressure gauge mechanism having a special insulated hand which, upon coming in contact with a conducting stud at the position of minimum pressure, will allow current to pass through one solenoid, thus closing the main switch, and upon coming into contact with another stud at the point of maximum pressure will allow a current to pass through the other solenoid, thus opening the switch by moving the plunger in the opposite direction.

The complete motor compressor is usually mounted in a box and cage suspended underneath the car body, though it is sometimes placed under a car seat. The method of enclosing the compressor in a box in this way is found to give, on the whole, more satisfactory results than is the case of a totally enclosed motor and the whole machine exposed to the elements. Both types of compressor are manufactured by the National Electric Company of Milwaukee, who own the patents and manufacture all the apparatus required for the Christensen air-brake system.



AUTOMATIC ELECTRIC GOVERNOR.

The engineer's valve usually adopted is of the rotary patent, though a slide valve type is also made. In construction, of course, it differs very widely from that of the three-way cock from which it was developed, since it has to meet the special conditions of admitting the air to or from the brake cylinder at any rate required by the motorman so that the brakes may be

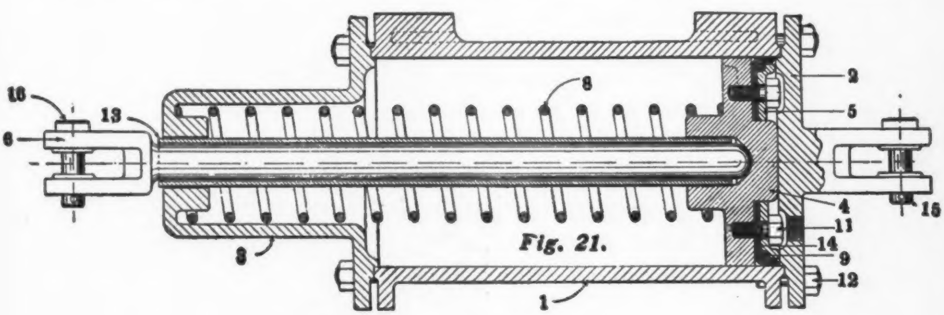
gradually or quickly applied, thus giving the motorman a very complete control over the braking of his car. There are five

ENGINEER'S VALVE.

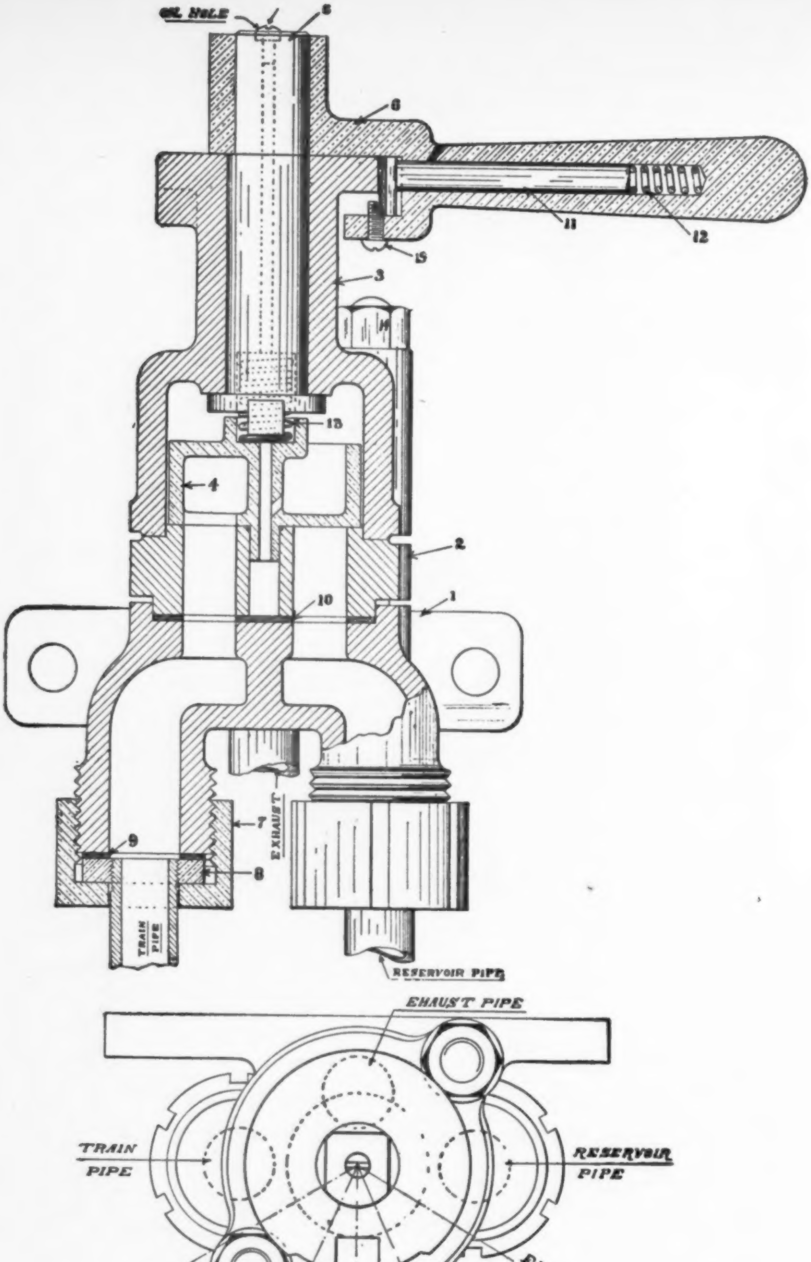
main positions for the valve handle—namely, those of quick release, slow release and running, lap, and service stop and emergency stop. These positions being marked by off-sets on the flange of the valve cap with which a spring actuated pawl, arranged directly in the handle, comes in contact. The driver can thus feel in what position his valve is without the necessity of having to look at it; of course he can use intermediate positions at will. With the engineer's valve in lap position, all the ports in the seat and in the rotary plug are blanked so that there is no communication between any of the three ports in the seat whatever. The handle is removable from the valve only in this position. This serves various objects, the principal one being that by removing the handle this valve is rendered neutral. It is also possible to set the brakes with this valve, then move the handle to lap position, remove it to the other end of car and release the brakes with the valve on that end.

If the proportions of the brake leverage are so calculated that the total braking force does not exceed 90 per cent. of the total weight of the car, including trucks and motors, but not inclusive of passengers, the maximum braking force possible can be exerted by the motorman without any fear of the wheels skidding.

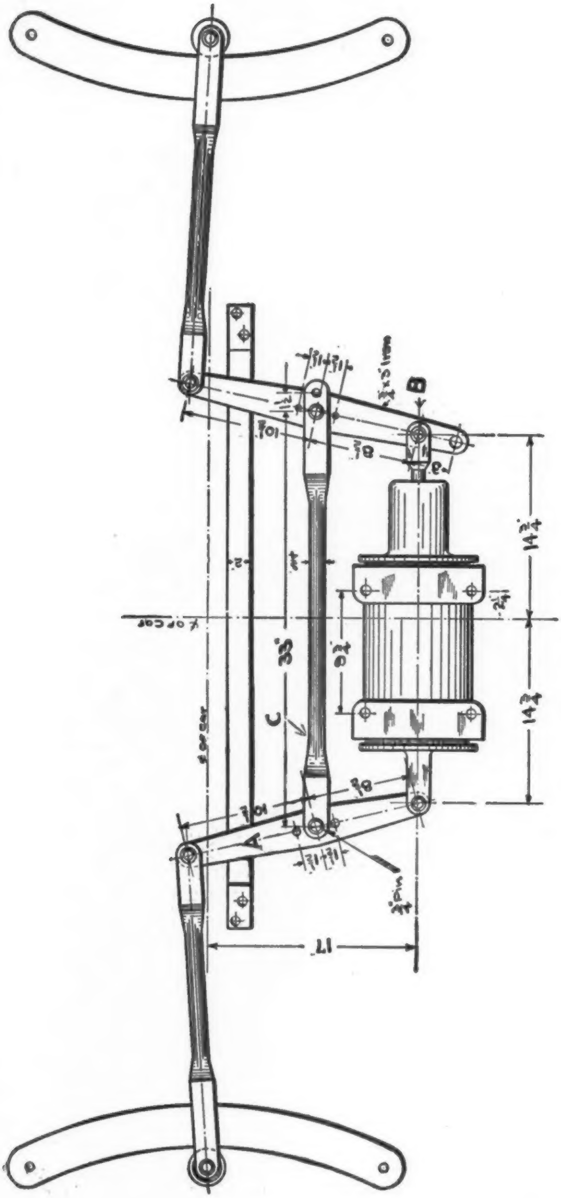
The brake cylinders are similar in construction to those used in steam railroad practice, with the exception that they are provided with loose piston rods so that if the hand brake is applied to the same brake rigging the loose rod only is moved, and the man in applying the hand brake therefore does not have to overcome the tension of the spring used to return the brake cylinder piston. The diagram herewith shows an arrangement of the foundation brake rigging and positions of the various portions of the apparatus which



SECTION OF BRAKE CYLINDER.



STRAIGHT-AIR ENGINEER'S VALVE.



TYPICAL FOUNDATION BRAKE RIGGING.

has been found to be most convenient and serviceable in operation.

The capacity of the compressor used depends of course upon the number of stops made per mile and the average speed of the car. For average conditions as are met with in American Street Railway practice the size known as AA-1 having a piston displacement of 11 cubic feet per minute is usually found to be the most suitable, used in conjunction with a 7-inch or 8-inch brake cylinder and brake leverage giving the required ratio. The same type of compressor is made also, having displacements of 20, 35 and 50 cubic feet.

Cars equipped with air brakes have the advantage that such auxiliary apparatus as whistles and air sanders can be added, though at the same time, especially in the case where the whistle is used, the compressor provided must be of larger capacity, the whistle often consuming more air than is required for braking purposes. The whistle, more especially in suburban service, has saved many an accident by its more penetrating sound, and the use of the same in a preconcerted system of signals. The special advantage of the pneumatic sander over that of the ordinary type is that the sand is blown directly under the wheel tread where it is most needed instead of falling a little distance away.

R. Borlase Matthews,
Wh. Ex., A. M. I. C. E.

The Power Drill Sharpener.*

When the modern air drill first came into use the single bit was replaced by the cross bit, owing to its greater cutting capacity and its lesser liability to follow slips and seams in the rock, which often resulted in the loss of a hole on account of being crooked.

The cross bit was forged from the octagon or round bar at that time in general use. To make these cross bits it was necessary to upset the bar to about twice its normal size for a distance of from 6 to 8 inches at one end previous to forming the cross. This was done in order that in redressing the bits a long stock of cross was available to work on. After this stock had been worked down, the bar was again upset as at first. This process of upsetting, especially by hand, was very expensive, as it was very laborious. In some of the larger mines in Michigan a large bolt-upsetting machine was installed to do this upsetting, which materially reduced this expense. The general use of these machines was not possible on account of their enormous cost. To overcome this, the drill steel makers began rolling out cross-formed bars of steel, to be cut into the desired lengths and then welded onto octagon or round bars. While this welding was expensive, it was cheaper than upsetting the bar, as was at first done, and this type of drill is in general use in the Rocky mountain mining districts.

When drill sharpening machines first made their appearance, one of the conditions met was that no two mines used exactly the same shape of drill. The only way that I can account for this is that the Creator did not make any two blacksmiths alike, and therefore each smith had his own peculiar form of drill. This difference in ideas often resulted in more or less trouble in the mine by the mixing of drills made by different smiths, and to overcome this a very wide range of gauge was adopted; in some cases a starter drill would be 3½ inches wide, and then they would drop ¼ inch in gauge as the lengths would change, and often the bottom of a 6-foot or 8-foot hole would be more than 2 inches in diameter. Into this hole so much powder was rammed that, instead of merely breaking the rock, it was pulverized to a sand. One-half the charge would have accomplished the desired result.

By the use of a power drill sharpener the gauge of the drills can be reduced to a size that is consistent with what is really wanted, and at no time should the gauge of the drill vary more than ⅛ inch. As these machines positively gauge all drills regardless of who runs them, it is possible to use smaller drills, and in this way put down from 25 per cent. to 40 per cent. more holes than with the same air consumption.

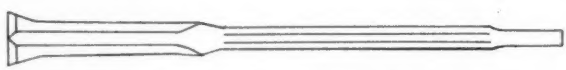
Practice has determined the fact that where 1¼-inch powder is to be used, the bottom of the hole need not exceed 1 7-16 inches. If the rock is so tough that 40 per cent. powder will not break it, then

*By T. H. Proske in the *Mining and Scientific Press*. Illustrations published through courtesy of *M. and S. Press*.

it is cheaper to increase the strength of the powder than to increase the size of the hole.

As the hardness of rock varies in the different mining districts, so must the drill vary to conform to these conditions; no matter what the depth of the hole is to be, the bottom should not exceed 1 7-16 inch diameter for 1¼ inch powder; if the hole shall be from 8 to 9 feet deep, and four lengths of drills will put it down, then the starter drill should be 1¾ inch wide as made by the machine, the second drill should be 1⅝ inch wide, the third, 1½ inch wide, and the fourth, 1⅜ inch wide. These drills will usually follow, especially where the cross-formed bars are welded onto the octagon bars; by the use of the power drill sharpener this welding is not necessary; neither is it necessary that the octagon bar be upset from 6 to 8 inches for stock; it is only necessary that there should be enough cross to sustain the bit, and usually 3 inches is sufficient for any size drill. The modern drill sharpener will easily forge this amount of cross and bit on the end of a bar without any hand work whatever, and, after having once forged it, it will maintain it until the bar is used up.

In some mines it has been found advisable to increase the size of the bushing



Type of drill used in Rocky mountain mining districts. Cross-formed bar welded onto octagon bar; shank forged to small bushing.

Type of drill used in Michigan copper and iron mines. Long cross upset in bolt upsetting machine from octagon bar.

Type of drill as made with a Power Drill Sharpener. Cross upset 3 inches long from round bar; no forging down of shank, as chuck bushing is large enough to take the full size of bar; the most economical drill that can be made.

cut 1-16 inch larger than their gauge, but should the rock be so hard that eight lengths of drills are required to put down a 9-foot hole, then the starter should be 2⅜ inches wide, the rest to follow at a ⅛ inch drop in gauge. In a number of tests made it has been found that machine sharpened drills lose their gauge about one-half as fast as hand sharpened drills, so the smaller the starter drill the less the drill has to cut, and the faster it will go into the rock. The reducing of the size of the drills can only be safely done where a machine is used for sharpening.

These are some of the economies already accomplished; there are more to in the chuck of the rock drill to take the steel without the necessity of forging down the shanks. This lessens the number of broken shanks, and even when a shank does break, the drill can be put back into the chuck at once without having to forge it down. In this way by using a power drill sharpener it is possible for one man to sharpen from 200 per cent. to 300 per cent. more drills than he can sharpen by hand, and on account of their accuracy in gauge they can be made smaller, and in this way the capacity of the rock drills underground is increased from 25 per cent. to 50 per cent., and by dispensing with the welding of drills and shanking them, the work on

the drills themselves in the shop is reduced fully 50 per cent. Machine sharpened drills will not stick, or cause rifled holes.

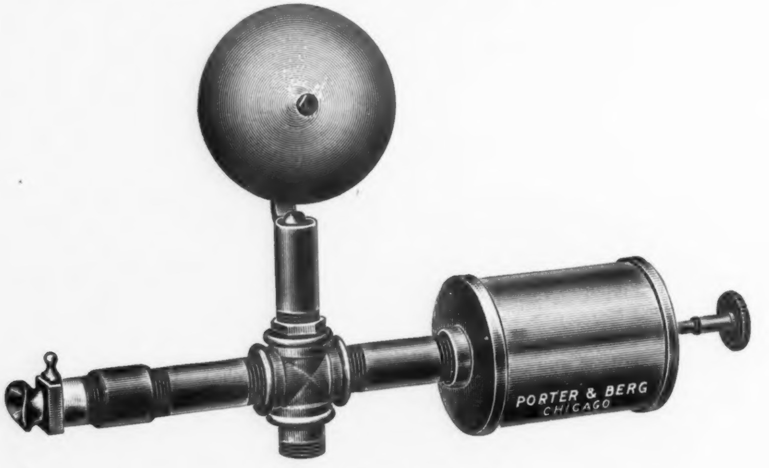
Pneumatic Signal Gong Attachment for Mine Speaking Tubes.

A device which will prove of value to mines is the pneumatic signal gong attachment for speaking tubes which has been placed on the market by Porter & Berg, Chicago. The accompanying illustration shows the outfit which is generally installed at each signal station or place at which signals are to be sent and received. Its installation makes a complete hoisting and communicating system between shaft, engine-house and tipple. The outfit consists of a heavy bronze gong, with stem, striker, brass air-chamber and an extra heavy brass speaking tube mouthpiece, with whistle. Necessary pipe fittings, as shown, are also furnished to connect the attachment to the pipe on which other such outfits are installed, thus making a complete hoisting signal and speaking tube system.

The air-chamber cylinder is fitted with a bronze plunger having a steel plunger rod, on the outer end of which is attached a bronze handle. The gong regularly furnished is 8 inches in diameter, made of cast bronze, and gives a loud, clear signal. The stem of the gong contains a striker which normally rests on a projection made by counter-boring the stem.

The operation of signaling is as follows:

The plunger of the air-cylinder at any station being pushed into the cylinder by the person making the signal results in producing a slight compression of air throughout the entire pipe circuit. This pressure in the pipe causes the strikers in the stems of all the different gongs to rise and strike the gongs simultaneously. At the same time a small amount of the air escapes through the whistle at all speaking tube mouthpieces, giving a whistle signal as well as a stroke of the gong. One stroke of the gongs and one sound of the whistles is obtained every time any one of the different air-cylinder plungers is operated. Any number of bells and whistle signals can be made by pressing the air-cylinder plunger the desired number of times.



SPEAKING TUBE AND GONG.

The speaking tube mouthpiece has a gate slide in which the whistle is fitted. When necessary to talk from one to any other of the stations on the signal circuit, this can be done by raising the gate slide in any speaking tube mouthpiece. It is impossible to leave the gate slide open after conversation has been concluded, as

it returns to its normal position by gravity, no springs being used.

The arrangement of the different signal stations can, of course, be changed to conform to different conditions which are to be met with in the various mines.

It is sometimes advisable to run a separate signal circuit from the weigh-room to the engine-house, using a different sized gong on the two signals. This enables the hoisting engineer to distinguish between signals given from the bottom and those sent from the weigh-room, each gong giving a separate, distinct signal.

At places where a gong is not necessary only the speaking tube mouthpiece and air-chamber need be installed.

Air Pump Failures.*

The air pump is the most important part of the air brake system, as all the others are absolutely dependent upon it. As indicating this, it is understood that the question has already been raised as to whether it is a violation of the Safety Appliance Acts for a train to be taken beyond the first sidetrack after the air pump has failed. This, and the interference with safe and prompt movement of traffic, shows the importance of preventing, as far as possible, air pump failures. Pump failures are of two kinds, complete and partial.

The complete pump failure is where it will compress no air. One cause is a loose air piston, due to the nuts coming off from the rod, the end of the rod breaking off or the rod cutting its way through the piston. Long experience has demonstrated to the writer that such failures are not due to construction, and cannot be prevented by any special form of lock nut or nut lock. Instead, they are due to improperly made repairs, through workmen being unskilled or careless, or having no suitable tools or repair parts. In fact, almost all such failures are results of round house repairs. For this and other reasons repairs to air pumps in round-houses should be confined to the least amount consistent with surrounding conditions. Those proper to make should be defined; it should be known that the men permitted to make these repairs have the necessary knowledge, and proper repair parts; and tools for doing this work should be furnished and used.

To prevent the air piston from coming loose it should be a light driving fit on the rod, the shoulder bearing should not be over 1-16 inch less than standard diameter of rod, the threads should be true and not enlarged near the end of rod by use of hammer or set, the two nuts should fit near enough to require a wrench to turn them, and they should be drawn firmly by means of a wrench of such length as will enable the repairmen to judge accurately of how well they are secured. To accomplish the last, both the pump and the piston must be secured against turning. Where the pump is on the locomotive a simple and inexpensive clamp will permit of holding the piston, but it is too frequently not had. The use of a chisel or set on the nuts should be prohibited under severe penalty for violation. The use of such means results in fractures to both nuts and rods, which often causes failures. Furthermore, it prevents assurance as to whether the nuts are properly tightened.

Hammering the end of the rod to remove the air piston is another cause for failure, and is inexcusable, as a simple and special form of jack can be employed which will obviate the need of such hammering.

Nuts that fit and are properly drawn, with a piston which fits its rod, will prevent failures. No special lock nut or nut lock can take the place of these precautions, or guard against failures if such precautions are not observed. The nickel steel piston rod has been suggested as a means to reduce breakage of the rod end, but as it is believed that these failures occur from abuse instead of use, it follows that such a rod would be of practically no benefit and yet would increase the cost of maintenance.

Probably the next most common cause of failure is the reversing plate cap screw working up. Some roads employ a simple form of lock, such as exhibited, and find that it absolutely guards against this cause of failure.

In the past the breakage of an air valve was sometimes followed by a piece entering the air cylinder, being struck by the piston and bending the latter, thus stopping the pump, but with the steel air valve

*A paper by Mr. W. Parnell, C., St. P., M. & O. Ry., read before the N. W. Ry. Club.

and seat now employed in tne 9½-inch pump this trouble is eliminated. Under no circumstances should the brass valve or air valve seat be allowed to remain on the discharge side, any such in pumps or in stock being worn out on the receiving side, where there is practically no danger of failure.

Some few failures have occurred through a bent or broken reversing valve rod. The reversing valve rod must be straight when applied, or this trouble will be liable to follow. For this reason the pump head should never be removed or replaced with the reversing valve rod in position, as otherwise the rod is almost sure to be bent. A badly worn reversing valve plate, such as was quite common before these were case-hardened, and a reversing valve rod fitting loosely where it passes through the reversing valve bush, have permitted the rod to slip sideways and be bent.

To the foregoing should be added for the 8-inch pump, failures due to non-standard dimensions of the main valve or loss of cushion on the up stroke by reason of defective reversing piston packing rings. Either is liable to cause breakage of the main valve.

The partial failures are those where the pump is unable to supply the needed pressure, causing shortage of air, stuck brakes and train delays, as well as reducing train safety. This type of failure is far more frequent than is generally appreciated. Where the fault is with the air cylinder, it increases the wear much more rapidly than equal service would do with the parts in good order. The most common cause is leakage by the air piston packing rings. Next in order is leakage by the piston rod or back into the air cylinder. While metallic packing is undoubtedly the most desirable, yet much trouble has been experienced from it owing to poor design or absence of the regular lubrication which such packing absolutely requires.

Leakage by the air piston packing rings or the air valves, particularly the discharge valve, causes excessive heating, destroys lubrication, and therefore, produces rapid wear as well as greatly reduced efficiency. There is almost as much reason for automatic lubrication of the air cylinders as of the steam cylinders, but as yet it is not demonstrated that an entirely satisfactory automatic lubricator has been invented for the air cylinder, though good progress is being made, in view of the recognized need for such.

Air cylinders should invariably be bored when 1-32 inch or more out of true, and in exceptionally severe service should be bored if 1-64 inch or more out. The air piston should fit the cylinder neatly, and should never be over 1-16 inch smaller in diameter. The piston packing rings of the air cylinder particularly should fit the grooves and the cylinder as accuratelv as possible.

A very much neglected feature is the suction opening. Tests made with a certain cylinder oil resulted in no gumming and choking of ports where made in a room free from dust, but with the same oil used in service the air cylinder ports choked up within two weeks. There can be no debate on the desirability of keeping dirt out of the air cylinder, not only to avoid gumming mentioned, but as well that it may not absorb the lubricating oil or increase the friction of moving parts. The present air strainer is not designed to exclude other than coarse dirt, and it is believed that a special form of strainer, with proper attention to keeping same in good order, would result in an immense improvement to the air cylinder. Another fault of the present strainer is the result of allowing it to choke up with gum. Even a clean outside is no indication that the air can enter as freely as necessary. Test made in the East showed that a strainer, no dirtier than frequently met with, required the pump to make 628 strokes and a time of 4 minutes and 8 seconds to acquire 100 pounds pressure on the engine. With the strainer removed but 540 strokes and 3 minutes and 30 seconds were required to obtain the same pressure. In winter engineers must watch carefully to guard against frost accumulating on the strainer and causing similar stoppage. Such accumulation is most liable where there is rising steam and when certain atmospheric conditions prevail.

Speed is another important factor governing the heating and wear of the air pump. With the high boiler pressure of to-day it is easily possible to drive the air pump at a very uneconomical and otherwise detrimentally high speed. Some roads have issued instructions that under no circumstances must the speed of air pump exceed 130 to 140, depending on the road, single strokes or exhausts, per

minute. Other roads, with the knowledge that there will always be some men who will fail to observe such instructions, have introduced a restriction or choke in the steam supply passageway, with the object of better insuring against excessively high speed. The object sought in both cases is commendable. While the choke has been criticised through the fact that when the boiler pressure becomes low it prevents as rapid pump speed as would otherwise be possible, on the other hand, by better insuring against abuses, it aids in maintaining a higher pump efficiency, so that it is probable that in the total the gain is much greater than any possible loss. Furthermore, although many locomotives with maximum boiler pressure of not over 140 pounds are fitted with 9½-inch pumps, we hear no complaint of brake trouble from insufficient pump speed, and it seems reasonable to assume that a choke sufficiently small to protect the pump with higher boiler pressure would be less detrimental when there is shortage of steam than would be the case with the low boiler pressure without a choke.

The condition of the pump being the same, besides speed, the air pressure worked against and time govern the heating. The duplex pump governor having the low pressure head connected to the feed port of the engineer's brake valve, as explained in the Westinghouse Air Brake Company's Bulletin No. 12, greatly reduces the pump labor and at the same time increases the effective pressure for releasing and recharging.

Where special service warrants a greater capacity than is possible with one 9½-inch pump, it would seem that two such pumps should be employed rather than one 11-inch pump, as this will give greater air capacity than the 11-inch pump and maintain standards in repairs. The slower speed and shorter duration of same resulting from the use of two pumps will greatly decrease the detriment of overheating. Furthermore, as it is out of the question that both pumps would fail at the same time, the use of two pumps per locomotive absolutely guards against an engine failure because of a pump refusing to work.

To reduce the pump failures it is necessary that defects contributing to these be early noted and reported. Engineers and round house repairmen shoull frequently make the following tests:

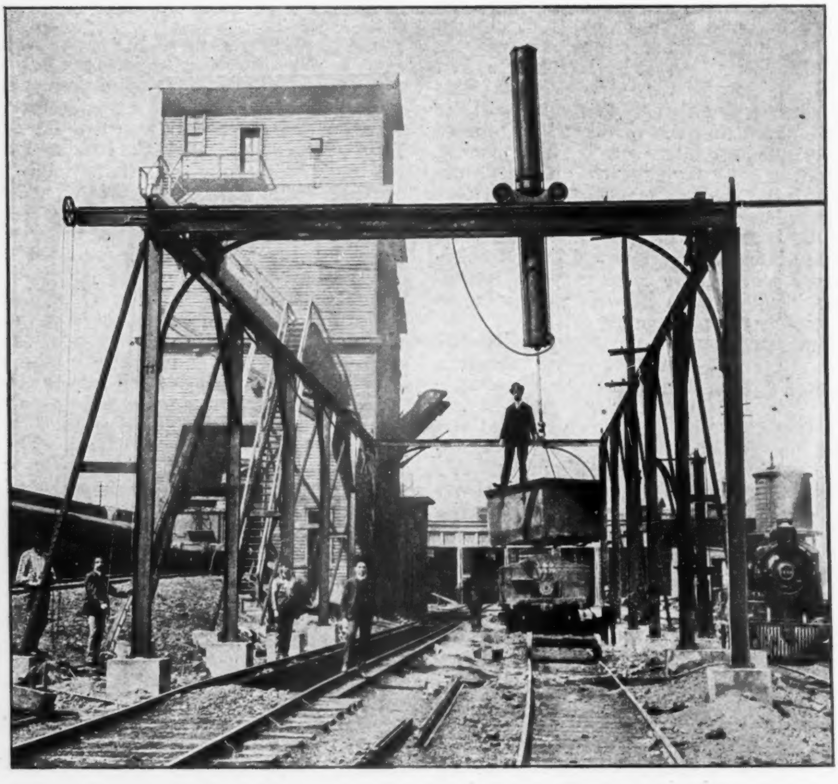
With the pump working against full pressure (about 85 to 95 pounds is satisfactory) note whether there is any tendency to stop when uncontrollel by the governor and whether there is any unusual click or pound. In the absence of these, open the oil cup on the air cylinder, with the throttle regulate the speed to 30 single strokes or exhausts per minute, and then on each down stroke note whether any air blows out of the open oil cup. Any such blow indicates serious leakage by the piston packing rings or back from the main reservoir, as moderate leakage would cause no blow owing to the space which must be filled as the piston descends. To complete this test, next stop the pump, and when the piston rod is at rest note whether there is any blow out of the cup. Any then existing is back leakage from the main reservoir, and is thus distinguished from leakage by the air piston packing rings. In addition to the foregoing, it should be noted whether the pump strokes are equal before the oil cup is opened.

A pump having a defective air cylinder will be indicated to the observing man without his having to make any particular tests. One sign of bad order is a suction over but a portion of either or both strokes when the pump is working slowly against full pressure, or where it blows back through the receiving valves. These should be determined by listening at the suction, and not by covering same with the hand, as this is an unreliable method of seeking for defects. Other signs of bad order are an unusual click or pound, unequal strokes, the pump stopping occasionally when not controlled by the governor, a silent working pump or one showing indications of heating through a burned appearance about the air discharge valves. Sticking air valves are also indicative of poor suction and is a condition which warrants not only cleaning the valves, but a test for leakage by piston packing rings or back from the main reservoir. In fact, sticking receiving valves should be remedied before attempting to test the packing rings or discharge valves.

In conclusion, attention is called to the indication of excessive heating due either to a bad order air cylinder or heavy and prolonged labor, through the odor of burning oil which can be observed by the engineer when the discharge temperature rises somewhere above 350 degrees to 370 degrees, being especially noticeable when the brake application is being made.

Pneumatic Ash-Handling Plant.

The ash-handling plant shown in the accompanying illustration was built for the Baltimore & Ohio by the Northern Engineering Works, Detroit, Mich. It consists of a steel runway 95 feet long, supported on steel columns securely braced against side laterally. On this runway is crane, bridge and trolley are fitted with "Northern" cage-type roller bearings and the wheels have machined treads to make the travel as easy as possible. The traveling chain on the bridge projects beyond the runway, but this chain can be located wherever desired on the bridge. The hoist is direct-acting and known as Type 20; it is mounted on a universal swing bear-



PNEUMATIC ASH-HANDLING PLANT FOR THE BALTIMORE & OHIO.

a 2½-ton direct-acting, air hoist traveling crane, of 28 feet span and a lift of from 12 feet to 16 feet. It is moved along the runway by means of hand chains and the travel of the trolley on the bridge is accomplished by the same means. The entire structure is designed to handle full loads with a factor of safety of five. The ing on the trolley. The working pressure is 80 pounds, the air being conveyed to the hoist by hose, carried along the runway on small hose trolleys over which it is looped.

In operation, the ashes and cinders are dumped from the locomotive into large metal ash boxes in the ash pit. These

boxes are lifted out by the crane and placed on a flat car alongside. The plant is cheap to build and to operate. If preferred the bridge and trolley can be moved by air motors, and for those roads having electric power, electrically operated plants can be supplied. These latter are more compact and efficient than the pneumatic plants. The builders supply the runway in any span and length desired, or the crane can be supplied alone, the buyer supplying the runway.—*Railroad Gazette.*

Notes.

Compressed air is now utilized to operate the turn-table of the Illinois Central Railroad at Freeport, Ill.

Postal pneumatic tube systems are to be installed in Montreal and Toronto. Bids are being secured for the work.

The Tennessee Cotton Harvester Company, capital $10,000, has secured a charter in Tennessee to manufacture and sell cotton pickers operated by steam or compressed air.

Different types of Ingersoll-Sergeant air compressors are illustrated and the most pertinent points noted in a leaflet, form 35A, just issued by the Ingersoll-Sergeant Drill Co., of New York.

A "Boiler Room Chart," by Fowler, is an instructive chart just issued by the Norman W. Henley Pub. Co., New York. It shows in isometric perspective the mechanisms belonging to the modern boiler room.

Users of compressed air, who are interested in the steam turbine as a means of power supply, will find an interesting book in the pamphlet issued by the Westinghouse Machine Co., of Pittsburgh, Pa., on the "Westinghouse-Parsons Steam Turbine." It contains an exhaustive description of this machine.

The Sanitary Compressed Air Vacuum Company of New York has been incorporated at Albany, N. Y., with a capital of $1,000,000. The incorporators were J. T. Emery, Alfred Luttman and M. Holland, of New York. The company aims to carry on a general dust-removing, cleaning and renovating business.

The first of a series of bulletins describing "Labor Saving Tools Operated by Compressed Air" has just been issued by the Pneumatic Tool Department of the Ingersoll-Sergeant Drill Co., of New York. The first bulletin, No. 2000, illustrates and describes the MacDonald rivet heating forge. Those who desire the series of bulletins should send their names for the mailing list of that company.

Carl W. Maxon, West Bay City, Mich., has patented a pneumatic tire which incloses two air tubes with a valve for each tube and an asbestos cushion surrounding the tubes. The outer casing is formed of a mesh built up of asbestos-covered wires, with the whole covered with rubber. It is claimed for it the same elasticity as the ordinary tire, combined with the greatest durability and freedom from punctures.

Hans Nelson, of Lafayette, Wis., has proposed a new application of compressed air for increasing the speed of ships. His invention provides for the uniform distribution of a current of air, gas or other fluid between the hull of the ship and the water in which it rests, thereby reducing the frictional resistance of the vessel. He also plans to force compressed air longitudinally along the hull and in the direction opposite to that of the vessel.

The transfer of the A. S. Cameron Steam Pump Works' agency at Birmingham, Ala., to the Crane Company was made on account of the sale of the Milner & Kettig Company's stock to its successors, the Crane Company. Mr. W. H. Kettig, former president of the Milner & Kettig Company, is local manager for the Crane Company. The Crane Company has already taken over the stock of the Cameron pumps which will enable it to supply the trade in that vicinity.

The Tidewater Compressed Air Cleaning Company has been granted a charter to do business in Virginia, with a capital stock of between $5,000 and $15,000. The officers of the company are: J. W. Perry, president; W. Lee Powell, vice-president,

and Harry Lee Lowenberg, secretary-treasurer. The principal offices of the company will be in Norfolk, and the company will engage in the general cleaning of hotels, household and other buildings, steamships and vessels of all kinds.

While of course no engine is allowed to be run under its own power, the White Sewing Machine Company accomplishes the same purpose by having one of its regular cars mounted on jacks and run by compressed air. The air is supplied from the basement of the building, and is fed to the cylinders of the engine like steam. Under the car is a large mirror, and visitors are thus enabled to see the actual working of the parts which are usually hidden from sight.—*The Automobile.*

The Sullivan Machinery Company, of Chicago, announces the establishment of a new branch office in Salt Lake City, Utah, Room 128, Keith Building, Mr. John C. Taylor, formerly of the Denver office, manager. A full line of Sullivan straight line air compressors and rock drills, with mountings, equipment and duplicate parts, will be carried in stock, and inquiries for diamond core drills, heavy hoisting engines, coal-cutting machines and quarrying machinery will receive prompt attention.

Siepermann & Fudickar have secured the English patents for an air pump. In this pump water is forced under pressure into a container whose upper end is in communication with the chamber to be evacuated. Water enters the protruding vertical pipe, and carries with it some air, which it traps in alternating air and water cylinders all down the pipe, gravity accelerating the speed at which the water falls. By opening the top and inclosing the outlet in a sealed tank the air is compressed.

The General Pneumatic Transit Company, with a capital of $30,000,000, has been incorporated at Trenton, N. J. All the incorporators of record—Howard K. Wood, Louis B. Daily and Kenneth K. McLaren—are officers of the Corporation Trust Company of New Jersey. They merely represent the groups of financiers who will appear when the corporation assumes permanent form.

It is currently reported that the corporation represents a consolidation of the various pnuematic tube interests of New York and other cities, including the Batcheller Pneumatic Tube Company, the parent company of which John E. Milholland is president.

The purpose of a compressed air receiver is to reduce the pulsations of the air from the compressor, to collect water and grease carried by the air in the pipes. The receiver is not intended as an air reservoir of power, though to a limited extent it may be employed for this purpose, as in the event of sudden stoppage of the compressor for any cause the air in the receiver may have sufficient volume and pressure to accomplish some work, such as hoisting a skip in a shaft that had already been started by the engines which are run by compressed air. The extent to which the receiver may be used for this purpose depends upon the volume of air and its pressure. The principle is exemplified in the compressed air motors.—*Mining and Scientific Press.*

The Philadelphia Pneumatic Tool Co., through it president, Julius Keller, announces that it has assigned all its business, patents, trade-marks and good will to the Chicago Pneumatic Tool Co., and is to join interests with the latter company. Mr. Keller has become a director in the Chicago Co. and will have the direct management of the Philadelphia plant, which will be operated as before for the manufacture of Keller hammers, drills and other tools. It is understood that other officers of the Philadelphia Co., as well as the selling force, will be taken care of by the Chicago Co. The terms on which this transfer was effected are not divulged. Mr. Keller was made a director of the Chicago Co. at its annual meeting February 21 and the final transfer of the property was effected March 1.

The piercing of the Simplon Tunnel was completed at 7.20 o'clock on the morning of Friday, February 24. The boring operations began on November 13, 1898.

Many unexpected obstacles were encountered, the most serious being hot springs, which threatened to wreck the whole enterprise, and a temperature which at one time rose to 131 degrees

Fahrenheit, making a continuance of the work impossible until the engineers found means of cooling the atmosphere.

The construction company has contracted to have the tunnel ready for traffic on May 15, under a heavy penalty, but owing to the unexpected difficulties encountered, it is not likely, should the contract be broken, that the penalty will be enforced by the Swiss and Italian Governments, who have jointly financed the undertaking, share and share alike, at the cost of $15,000,000.

At a meeting of the Sheffield Students' Engineering and Metallurgical Society, held at Sheffield, Eng., February 7, Mr. G. Minnitt read a paper on "Sinking Foundations by Compressed Air."

The lecturer commenced by describing some of the difficulties which in the early days of excavation works had to be experienced by engineers, and explained that by the use of caissons, working with compressed air, it is now possible to make excavations under water, which, before the introduction of caissons, were almost impossible, and that the difficulties, incident to the kind of work, have been reduced to a minimum. Then followed detailed descriptions of the caissons used in connection with the erection of the Forth Bridge, the "Alexander the Third" Bridge, Paris, and the Canal Maritime de la Vasse Loire. The use and working of these caissons were also explained. The paper was illustrated with large-size drawings. A discussion followed.

A Sheffield firm has placed a new coal-cutting machine on the market that is creating much interest among miners in this part of England. It weighs only 150 pounds, is worked by compressed air, and is said to be wonderfully successful in lightening the labor of the coal hewer and in making his work safer, while at the same time waste is reduced to practically nil and the big lumps are produced which are so much in favor with both seller and purchaser. The machine is used in seams so steep that the miner cannot stand and so thin that he must crawl on hands and knees. A piston carrying a pick flashes backward and forward at terrific speed, perfectly governed by a clever valve movement. The pick never strikes twice in the same place, being gradually moved across the coal by the lever, making a continuous undercut. The work is said to be very easy, the machine being pivoted in a specially devised cone-cup. —Frank W. Mahin, *Consul, Nottingham, England, December* 23, 1904.

The absorbing topic among theatrical folks just now is the wonderful London Coliseum that was recently opened. This immense playhouse, with a dome as high as that of the world-famous St. Paul's Cathedral, three racetracks large enough to reproduce on them from start to finish the celebrated horserace known as "The Derby," and three marvelous revolving stages, is kept scrupulously clean by the St. Louis invention of a St. Louis man, Mr. John S. Thurman.

The problem of keeping such an immense building absolutely clean when four different audiences view the programme daily was considered a serious one by the proprietor, Mr. Stoll, who, though but thirty-four years of age, is proprietor and manager of over eighteen theatres and music halls, until he gave the Thurman Compressed Air Cleaning System a thorough trial. Despite the competition of many rival English concerns, "The American Invasion" again scored a victory and the American system was awarded the contract.—*St. Louis Dispatch.*

Compressed air is soon to be put to its severest test in the building of the tunnels under the East and North Rivers in New York City. This undertaking will make heavy service demands, as once the work is under way no interruption can be permitted, and to meet the requirements every refinement has been applied in the construction of the big plants which could contribute to economy and reliability. The installation of air compressing machinery is to be the largest ever made for general power purposes, as compressed air is to bear the greater part of the burden of pushing the immense tubes under the rivers. Low pressure air will be used for keeping out the water and mud as the shields are driven forward and high pressure will be used in running the rock drills, driving concrete mixing machines, and possibly for pneumatic haulage. Four parallel tubes 33 feet in diameter are to be built between Long Island and Manhattan, the work being

carried on from both ends, while two tunnels will be built under the North river. —*Chicago Tribune.*

Every possible opportunity to utilize the gravity system is taken advantage of to the fullest extent, and everywhere where machinery will do the work more thoroughly, more rapidly and more economically than by hand, that machinery is installed. This is especially noticeable in the matter of drilling, which in every mine of importance is now done by the agent of compressed air. By this method one of the miners at Cripple Creek has already opened about thirty miles of drifts and crosscuts, and is adding to the total at the rate of about four miles per annum. The work has resulted in the discovery and development of many million dollars' worth of ore, which now await production.

Three large electric power plants furnish power for hoisting, running compressors, electric drills, and for lighting the mines, both above and underground. Two of these power plants are located in the Cripple Creek district; the other is located in Canon City, near the coal mines, and the power is transmitted a distance of 25 miles.—*Mining Investor.*

In connection with the investigation conducted by Prof. G. W. Bissell, of the Iowa State College, on the condensation occurring in indirect pipe-coil heaters for fan systems of warming and ventilation, a special draft gauge was developed. The air pressures in the heater casings were measured by means of this gauge connected by rubber tubing to ¼-inch iron pipes with carefully squared ends, which projected into the interior of the heater duct at the points desired. The apparatus was the result of experiments to secure a satisfactory multiplying draft gauge and was found to meet all requirements as to accuracy, quickness of operation and delicacy of measurement. It consists of a tank of water in which a weighted float is suspended from a spring balance and under which float the compressed air is introduced through the curved inlet tube. By sufficiently weighing the float the scale pointer was made to revolve around the dial and its point of rest taken as the gauge zero. The instrument was then calibrated, and a dial was prepared from the calibration to read directly in inches of water pressure. It was found, according to Prof. Bissell, that 0.001 inch could be accurately read.

A long distance pneumatic tube system has been proposed to transmit mail and express matter between Chicago and Milwaukee. This is a distance of 84½ miles, but packages would make the journey in only 40 minutes by the proposed tube, which would have a speed of about 120 miles per hour. The tube is intended to be 18 inches in diameter, laid entirely underground. It would convey loads up to 500 pounds, and would be run in relays of from two to three miles each, each section operating independently of the others, power automatically being cut off from a section upon the entrance of the mail carrier into the following section. The carrier would not be forced through the tubes by means of high pressure, as in other systems, but would be carried along by a vacuum. The cost of installation of such a plant would be $5,000,000, but the cost of operation and maintenance of the system would be so low that it is figuerd that the company could afford to carry 500 pounds for 15 cents.

As yet there are no long-distance pneumatic tube systems in operation, but contracts for several are now pending. Quite a number of systems of lesser length are now in operation in the United States, the longest of which serves the Chicago Post-office. This system is 9 miles long, and connects various postal and railway stations in Chicago with the old post-office building. It has a capacity for carrying 3,000 letters per minute each way, and cost $650,000.—*Machinery.*

The final report of the Royal Coal Commission, of England, contains the following regarding coal-cutting machines:

"Briefly stated, the chief advantages of coal-cutting machines are, according to the evidence: (1) That an increased percentage of large coal is obtained, and the coal got is in a firmer and better condition. (2) A more regular line of face is obtained, which facilitates ventilation and leads to more regular and systematic timbering, and the weight being more regular and uniform the roof can be

more easily kept up. The greater rapidity of working also tends to keep down the cost of repairs, and causes less damage to overlying seams and the surface, the subsidence being more even. (3) The regular and systematic working tends to increase the safety of the workmen. (4) Seams, which either because of their thinness or hardness, or both, could not be worked at all, or could only be worked at a profit in good times, can be worked profitably by machines. (5) Holing is less frequently done in the coal and, when it is, there is much less 'small' made than in the case of holing by hand. (6) The output is increased, and is more regular, and the work is more easily superintended. Fewer explosives are used for getting down the coal; in some cases none. Generally machine work is less costly than hand work, especially in thin seams. According to one witness the saving is much greater in the narrow work or headings than in the longwall faces. From the point of view of the men the work is safer and easier, and the wages are better. The importance of lightening the labor of the men will probably be more appreciated as the working places become deeper and the temperature becomes higher."

At the February meeting of the South Staffordshire and East Worcestershire Institute of Mining Engineers, Mr. W. Lynch read a paper on "Pneumatic Coal-boring Machines and Tools," and exhibited examples of pneumatic tools. In the course of his paper Mr. Lynch said he had been told by mining engineers in this district that a rotary power drill was badly wanted, as the material they had to drill into when driving drifts was too soft to admit of the percussion type of drill, owing to the tool clogging. He therefore experimented in one of the local mines three years ago with ordinary pneumatic drills, such as were used in boiler works, but this was not a success, as the feeding had to be done by hand and not automatically, as with the two rotary machines which he had brought for inspection. The great feature of the pneumatic tool was its portability. The exhaust from pneumatic tools helped to ventilate the pit and keep the place cool, whereas steam-driven machines had the opposite effect. After describing various types of rotary and percussion drills, Mr. Lynch expressed the opinion that there was a very much larger scope for the use of rock drills in this country than has up to the present obtained. In the course of the discussion which followed the reading of the paper, Professor Redmayne said he had never questioned the use of power drills under certain conditions, but he believed that unless the rock was exceptionally hard and crystalline it was cheaper to keep to the old method of hand-drilling. There was no doubt, however, that in driving drifts through very hard rock hand-drilling would hardly touch the rock, and in those cases the only question was whether the rotary or the percussion drill should be used. When he went through the Cleveland ironstone mines he was told that the percussion drill could not compete with the rotary drill there. With regard to the drill which Mr. Lynch had shown with an arrangement for blowing out the dust, he pointed out that this would increase the evil of dust in the atmosphere of mines, which was causing some anxiety at the present time. He believed that it had been proved that tuberculosis was caused by the action of crystalline dust on the lungs. What they wanted was an arrangement for spraying the hole while it was being bored. He did not think it likely that power drills would be generally adopted in coal mines because hand-drilling was good enough for coal and was cheaper. Mr. T. H. Bailey said the pneumatic drill was not so suitable for coal-mining as for engineering work, because they would have to take the pipes thousands of yards in a mine in order to do a few hours' work.

There is no question, but what owners of ice-making and cold storage plants would further their interests by encouraging the systematic taking of indicator cards by their engineering corps.

It would well pay the owner to provide instruments for this purpose, but without the proper instruction or guidance for either himself or his engineer the money so spent would probably be wasted.

The engineer is not living who can look at an indicator card taken from a compressor and knowing whereof he speaks say, "This is a good card," without previously making some calculations.

Hence, on the engineer's ability to make the necessary calculations hinges the value of indicating the compressors,

unless it is found possible to lay down a few simple rules for him which can be applied to the cards taken. If the engineer is ambitious, and if his employer is progressive, the purchase of indicators, planimeters and the available literature on indicating compressors will furnish him with the necessary simple rules and instruction. Where, however, the engineer is not very ambitious and is willing to plod along in the old rut, it becomes necessary for a progressive owner to bring in outside talent; to devise means for keeping himself informed, as near as may be, of the condition and efficiency of the compressors operating in his plant.

That such a system can be devised by competent specialists in refrigeration is our belief, but the active co-operation of the owner will be necessary to its success.

The engineer, whether ambitious or otherwise, should be required by the owner to take indicator cards at regular intervals, say every day one card off one cylinder, or every week several cards off of all cylinders.

A careful study of such cards with the assistance of text books extant will soon familiarize, even the tyro, with their essential features. The average engineer when shown a card with a square heel will pronounce it a "good card," and those with round heels "bad cards, with too much clearance," they being bad in proportion to the amount of rounding off of the heel.

The compression line, however, receives little attention, if any, unless indeed the compressor is in very bad shape, and even then no intelligent deduction is made, as a very bad compression line may be "fair to look upon."

In short, have your engineer take indicator cards, plot the adiabatic and isothermal curves on each card and learn to analyze them. If he cannot do it, learn to do it yourself, and if you have not the mechanical instinct to a sufficient degree get a competent somebody to devise a system that will give you a line on your engineer and your plant. *Do something and do it soon.* You will save yourself money.—*Coal Storage and Ice Trade Journal.*

The following questions and answers were published in the *Technical World:*

Questions—1. What is ordinarily the limit of pressure upon a compressed-air tank used for driving machinery or operating tools?

2. What would be the capacity in cubic feet of air of a tank 6 feet by 2 feet?

3. How much work would be practically required to fill the tank to its capacity?

4. With a compressed-air engine of ordinary efficiency, how many horse-power could be developed with such a tank?

5. What is the efficiency of an ordinary compressed-air engine when the pressure in the tank is quite low?—A. F. S.

Answers—1. The ordinary pressure at which compressed air is used is 100 pounds gauge. For certain special work, however, pressures as high as 2,000 pounds per square inch are used. The compressed air used in operating engines of torpedoes is compressed to this pressure.

2. The capacity of the tank 6 feet long would be equal to its length multiplied by the area of its cross-section, which in this case gives:

$$6 \times 3.1416 = 18.8496 \text{ cubic feet.}$$

3. For each cubic foot of air compressed per minute to 100 pounds gauge pressure, there is required 1.5 horse-power. Since there are 18.85 cubic feet, the total power required to do the compression in one minute is 18.85×1.5 ($=29$) horse power. This is equivalent in round numbers to $30 \times 33{,}000$ ($=990{,}000$) foot-pounds.

4. The exact horse-power that could be developed by using the compressed air stored in the above tank would depend upon the rate at which the air is used, as well as the pressure of the air in the tank. The efficiency of the system starting with the work done in the compressor would be about 50 per cent. As shown above, the work performed was 990,000 foot-pounds. Allowing, then, for an efficiency of 50 per cent., the available work would be 495,000 foot pounds. The available horse-power would depend upon the rate at which the air is used. If used for one minute, the horse-power would be:

$$\frac{495{,}000}{33{,}000} = 15.$$

If, on the other hand, we wish to run a motor for one hour on the supply in the tank, the available power would be only $^{15}/_{60}$ (or $\frac{1}{4}$) horse-power.

5. The maximum efficiency of an en-

gine of any size is in the neighborhood of 80 per cent.—that is, of the total stored energy in the compressed air, the engine will develop at the brake .8. While the efficiency of compression is considerably lower at high pressure, yet, when used in a motor, the efficiency varies but little with different pressures.

A demonstration of a new type of pneumatic boiler riveter, manufactured by Messrs. John Turnbull, Jr., & Sons, No. 190 West George street, Glasgow, was recently made at the Grangemouth Shipbuilding Yard.

The riveter has a reach of 84 inches, and is capable of driving 1¼-inch rivets. It works on the principle of hand work, forming the head of the rivet by a succession of rapid blows. As will be seen from the illustration, the riveter consists of two levers, having at one end a pressure cylinder 13 inches diameter to open and close the levers; at the other end the riveting machine on one arm and a suitable die or counterweight on the other. There are three sizes of this type of riveter, namely, 72-inch, 84-inch and 96-inch reach respectively. The riveting machine proper consists of a cylinder, with the hammer head or die shaped on the end of piston rod; and, of course, the holder-on has a cupped rivet set which is interchangeable.

These riveters when first introduced had a movable rivet set or die, which was attached to the end of the piston rod, but from experience it has been found that more satisfactory results can be obtained by forming the rivet set or die out of the solid piston.

The valve is operated directly by the pressure in the hammer cylinder with extra gearing, and so arranged that the length of stroke regulates itself automatically to correspond with the gradual reduction of the end of the rivet as the head is formed. The air pressure required is from 30 pounds to 50 pounds per square inch, and the number of strokes per minute is from 150 to 200. The time required to form the head of, say a ¾-inch rivet, is about 6 seconds, and at steady, straight work, allowing for ordinary detention and loss of time, two or three rivets can readily be finished in one minute.

The machine can be worked either vertically or horizontally, and the operation is as follows: The rivet boy, after inserting the hot rivet, moves the die and weight over the head of rivet when the operator admits air into the cylinder by moving a rod, thereby closing the long ends of the bars and pressing the nozzle upon the plates over the rivet. The plates are held together by a pressure of about 2,000 pounds. The operator then presses upon the spring valve, admitting the air pressure into the riveter to operate its hammer, and this forms the rivet head by a succession of rapid blows.

In the Grangemouth Dockyard experiments were made on flush rivets, panhead rivets and snap-head rivets, all with success. The rivets were ⅞-inch diameter, and the plates ½-inch thick. After the samples were sawn up they exhibited a perfectly driven rivet and the plates tightly closed.

These machines are considerably cheaper than hydraulic riveters of the usual type.—*The Practical Engineer (Eng.)*

INDEX.

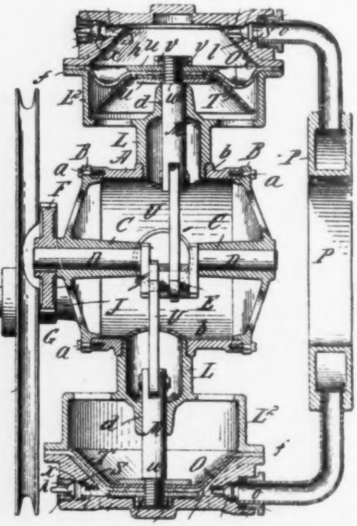
U. S. PATENTS GRANTED FEB., 1905.

Specially prepared for COMPRESSED AIR.

781,632. PNEUMATIC SHUTTLE-THROWER. Ezekiel C. S. Cobb and Samuel T. MacMullen, Wilmington, Del. Filed Nov. 28, 1903. Serial No. 182,966.

A pneumatic shuttle-thrower, the combination of a cylinder at each side of the loom, a piston-rod extending across the loom and having shuttle-throwers connected thereto, and a pneumatic buffer connected to said piston-rod.

781,678. AIR-COMPRESSING MACHINE. Clarence H. Richwood, Boston, Mass. Filed May 17, 1904. Serial No. 208,439.

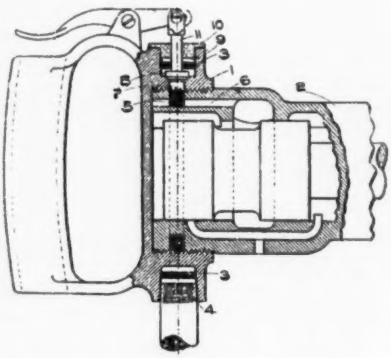


An air-compressing machine, in combination, a central body or support having a plurality of axially radial casings therearound, having valved air-inlet, and valved air-outlet openings thereto and therefrom, a reservoir, and conduits connecting the same with the air-outlets, flexible diaphragms in said cases, and rods connected respectively thereto, having guide-bearings for rectilinear movements through bearings therefor which are supported by the central body, a driving-shaft having a crank mounted for rotation in the central body, pitman-rods severally connecting with the crank and with the respective diaphragm-rods, and means for rotating the said shaft.

An air-compressing machine, in combination, a central body or support having a plurality of axially-radial casings therearound, each having its outer circular wall of flaring form, and having valved air-inlet openings and valved air-outlet openings provided with screw-threaded orifices, a reservoir, and rigid conduits connected therewith and having end flanges entered with the threaded orifices of the said outlet-openings, annular coupling-nuts engaging the end flanges of said conduits, and screwing into said threaded orifices, said conduits constituting the supports for the reservoir, flexible diaphragms in said cases, and rods connected respectively thereto, having guide-bearings for rectilinear movements through bearings therefor which are supported by the central body, and carrying, next to the flexible diaphragms, rigid flaring diaphragm-followers, a driving-shaft, having a crank, mounted for rotation in the central body, pitman-rods severally connected with the crank and with the respective diaphragm-rods, and means for rotating the said shaft.

781,687. FORMER OR MOLD FOR MAKING PNEUMATIC TIRES OR THE LIKE. Thomas Sloper, Devizes, England, assignor to Christian Hamilton Gray, Silvertown, Essex, England. Filed Mar. 12, 1904. Serial No. 197,868.

781,942. HANDLE FOR PNEUMATIC TOOLS. George H. Gilman, Franklin, Pa., and John Player, River Forest, Ill. Filed May 26, 1904. Serial No. 209,964.



A handle for pneumatic tools, a hand piece or grip, a socket integral therewith, adapted to the attachment of the cylinder of the tool, a valve-cylinder at the top of said grip, in longitudinal alinement with said socket, an air-inlet duct in said socket in longitudinal alinement with said grip and leading into said valve-cylinder, a passage leading from said valve-cylinder to the

cylinder of the tool, a valve in said valve-cylinder and means of manipulating the same substantially as and for the purpose specified.

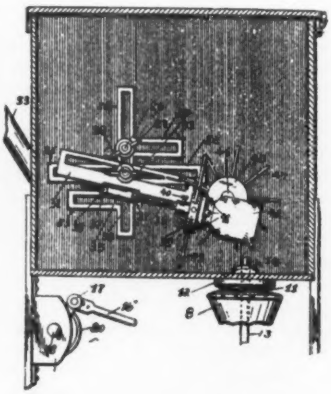
781,716. PNEUMATIC CAR-BUFFER. William W. Dennis, Cincinnati, Ohio. Filed Apr. 22, 1904. Serial No. 204,389.

781,767. VACUUM HEATING SYSTEM. John Collis, Des Moines, Iowa, assignor to William P. Collis, New York, N. Y. Filed July 3, 1903. Serial No. 164,127.

781,862. EXPANSION-JOINT FOR FLUID-PIPES. Henry A. Allen, Chicago, Ill. Filed Apr. 4, 1904. Serial No. 201,475.

An expansion-joint for piping, the combination of a casing having an internal bearing-surface describing a section of a hollow sphere with an inlet or outlet opening through it and a similar opening in another part, a pipe projecting into the casing through said first-named opening, and a bowl on said pipe, of metal adequately flexible to adapt it to be flexed, under fluid-pressure exerted upon its concave surface, against said bearing-surface.

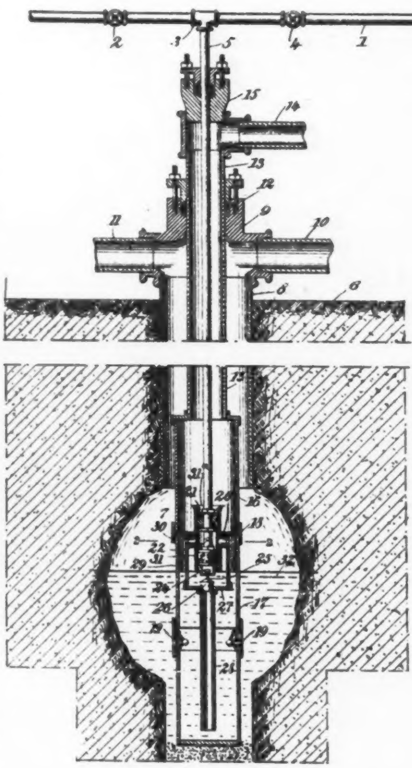
781,965. SAND-BLAST APPARATUS. Frederick W. Reinhardt, Monaca, Pa. Filed June 18, 1904. Serial No. 213,129.



A device of the type set forth, the combination of a casing, a sand-receptacle arranged below said casing, a pipe passing through said sand-receptacle and into said casing, means for sustaining an article within the casing, means for projecting sand through said pipe into said casing, and means for maintaining the sand-receptacle in motion while the sand is being projected through the said pipe.

A sand-blast apparatus, the combination of a casing, a receptacle arranged below the same and adapted to hold sand, a pipe passing into said casing and into said receptacle, means for sustaining an article in proximity to the end of said pipe, and means for creating a vacuum in the casing so as to suck the sand through said pipe and impel it against the article to be operated on.

782,040. APPARATUS FOR RAISING LIQUIDS FROM DEEP DRILLED WELLS. Thomas F. Moran, De Young, and Fred J. Moser, Kane, Pa.; said Moran assignor to said Moser. Filed Dec. 19, 1903. Serial No. 185,825.

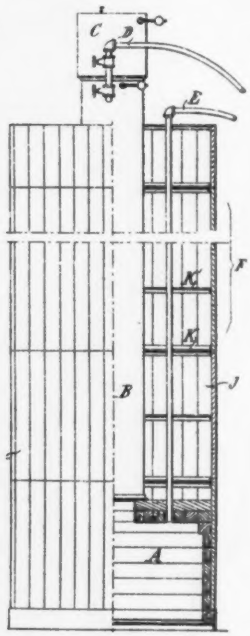


An apparatus of the character described, the combination of a casing provided with a partition separating the same into upper and lower com-

partments, a tubular member connected with said partition and provided with apertures disposed below the same, an air-pipe provided with packings engaging said tubular member and the apertures disposed intermediate of said packings, the apertures of said air-pipe being disposed adjacent to said apertures of the tubular member, a conductor-pipe in communication with said upper compartment and extending into said lower compartment to a point adjacent to the bottom thereof, and means for preventing retrogression of the liquid from said upper compartment to said lower compartment.

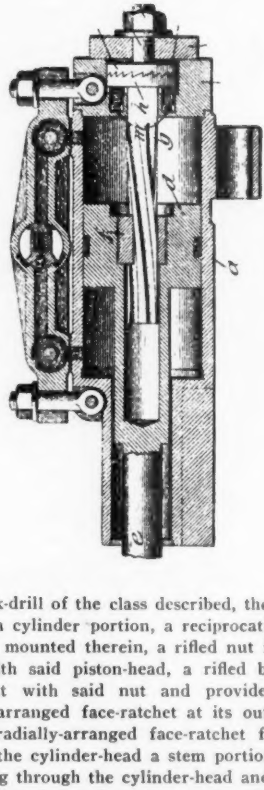
The combination of a casing, a partition disposed within the same, an air-pipe disposed partially within said casing and loosely engaging said partition, and a valve for preventing retrogression of liquid through said partition, said air-pipe and said valve being removable at will from said casing while said casing is installed in the well.

782,410. COFFER-DAM. Daniel E. Moran, Mendham, N. J., and John W. Doty, New York, N. Y. Filed Aug. 12, 1904. Serial No. 220,555.



A pneumatic caisson, a coffer-dam composed of sections having free vertical edges, each of which edges is adapted to be connected to an adjacent vertical edge to form a closed joint, and whereby a closed ring may be formed.

782,429. ROCK-DRILL. Robert Temple, Denver, Colo., assignor to The Temple Gas Engine & Machine Company, Denver, Colo., a Corporation of Colorado. Filed Dec. 18, 1903. Serial No. 185,702.



A rock-drill of the class described, the combination of a cylinder portion, a reciprocating piston movably mounted therein, a rifled nut in engagement with said piston-head, a rifled bar in engagement with said nut and provided with a radially-arranged face-ratchet at its outer end, a second radially-arranged face-ratchet frictionally held in the cylinder-head a stem portion therefor extending through the cylinder-head and provided with a threaded end portion, a threaded nut on the threaded end of said stem-portion, a yielding washer inserted between the second ratchet and the cylinder-head to hold the same in frictional engagement with said cylinder-head, and spring mechanism engaging the first-named ratchet, so as to normally hold it and thereby the rifled bar in engagement with the second ratchet substantially as described.

782,106. PNEUMATIC CARRIER. Charles H. Burton, Boston, Mass., assignor to American Pneumatic Service Company, Dover, Del., a Corporation of Delaware. Filed Feb. 15, 1904. Serial No. 193,522.

782,136. SPIRIT-BLOWPIPE. Albert H. O. Jackson, Brookwood, England. Filed Mar. 7, 1904. Serial No. 196,940.

A compound blowpipe comprising a spirit-reservoir, a compressed-air conduit adjacent thereto, a burning-nozzle having a contracted outlet attached to said air-conduit provided with perforations in one of its walls for admitting the outside air to the interior thereof, and means for supplying spirit to said nozzle, substantially as described.

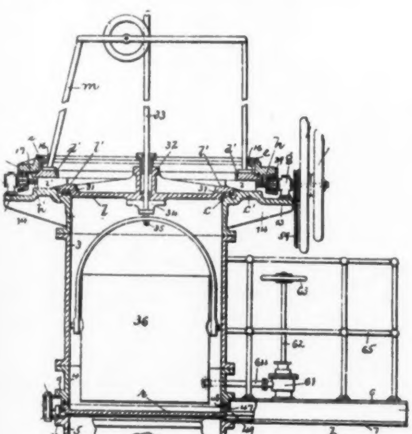
782,155. PNEUMATIC TIRE. Carl W. Maxon, West Bay City, Mich. Filed July 11, 1904. Serial No. 216,168.

782,383. CAISSON OR COFFER-DAM. John W. Doty, New York, N. Y. Filed July 2, 1904. Serial No. 215,055.

A coffer-dam having stiffeners extending transversely of its principal members, and having a substantially smooth inner face.

782,469. CONTROL APPARATUS FOR RECOILING GUNS. Charles P. E. Schneider, Le Creusot, France. Filed Aug. 17, 1903. Serial No. 169,818.

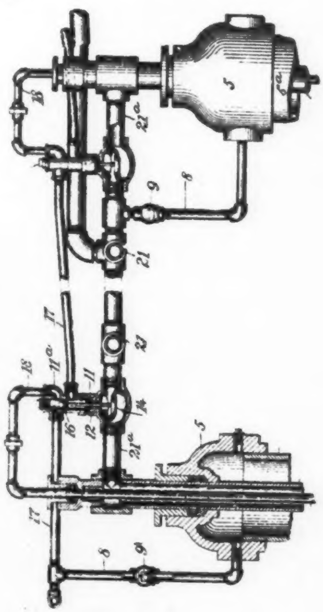
782,596. AIR-LOCK. Cesare Campus, New York, N. Y. Filed Dec. 6, 1904. Serial No. 235,719.



An air-lock and in combination, a longitudinal casing, a transverse casing, an upper gate, devices for forcing said upper gate against its seat and holding the same in position thereon, means for simultaneously operating said devices, a lower gate and means for swinging said lower gate to and from its seated position.

An air-lock and in combination, a longitudinal cylindrical casing, an upper gate, a seat for the same, devices for forcing said upper gate against its seat and holding the same in position thereon, means for simultaneously operating all of said devices, a transverse elliptical casing, a lower gate, a seat for the same, a block revolubly mounted within the elliptical casing, a strap passing around the said gate and having its ends secured to the opposite sides of said block, rollers, bearings for the same secured to said strap, a spacing-block, extending between the respective members of said strap adjacent to the said lower gate, a shaft passing into the said transverse casing and having its end secured within said block, means for imparting a partial revolution to said shaft to turn said block and thereby swing the lower gate to and from its seated position within the elliptical casing, and means for indicating the position of the lower gate within the elliptical casing.

782,681. OIL-WELL SYSTEM. Fred J. Moser, Kane, Pa. Filed July 16, 1904. Serial No. 216,835.



An oil-well system, the combination of a compressor, a receiving-tank connected therewith for

storing an aeriform body under pressure, piping extending from said receiving-tank to a plurality of wells, mechanism in each well for lifting a fluid therefrom, said mechanism being actuated by pressure of said aeriform body, and a plurality of controller-valves disposed at the several wells and connected with said mechanism thereof for the purpose of automatically shifting said pressure of said aeriform body from one of said wells to another in succession.

The combination of a pipe-line, a plurality of wells disposed at intervals along the same, an air-chamber disposed adjacent to one of said wells, an inlet-pipe connected with said air-chamber for admitting an aeriform body into the same, means for forcing said aeriform body through said inlet-pipe, an outlet-pipe leading from said air-chamber into said last-mentioned well for the purpose of raising a liquid therefrom, another outlet-pipe leading from said air-chamber to the inlet-pipe of another air-chamber located at another well, a movable member connected with said air-chamber for controlling the flow of said aeriform body through said outlets, and mechanism connected with said air-chamber and actuated by the flow of liquid from the well immediately adjacent thereto or shifting said movable member and thereby changing the course of said aeriform body from one of said outlets to the other.

782,696. TRACK-SANDER. Albert B. Potts, Chattanooga, Tenn. Filed Oct. 17, 1904. Serial No. 228,711.

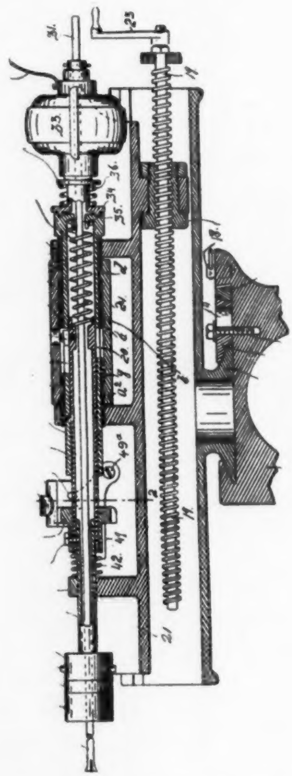
782,701. MEANS FOR CLEANING OUT THE BORE OF GUNS. Frederick L. Sawyer, U. S. Navy, assignor to John J. Knapp, trustee, Washington, D. C. Filed May 26, 1904. Serial No. 209,951.

The combination with an air-pipe at the breech of the gun, with a plurality of air-ducts leading from said pipe into the screw-box exterior to the breech-plug, a valve normally controlling the admission of air to said pipe, means for supplying compressed air to said valve, and means carried by the gun for opening said valve, substantially as described.

782,786. TROLLEY-POLE CONTROLLER. Joseph P. Magney, Los Angeles, Cal., assignor to The Magney Manufacturing Co., Los Angeles, Cal. Filed July 11, 1904. Serial No. 216,041.

A pneumatic trolley-holder, the combination of an air-cylinder, piston therein, a vibrating trolley-pole support, connections between said support and said piston, whereby the pole is elevated by the piston, a supplemental air-cushion piston in said cylinder, a valve for controlling the admission and exhaust of air to and from said cylinder, a spring for closing said valve and opening the exhaust, and connections for controlling said valve by the position of the trolley-wheel, substantially as described.

783,032. ROCK-DRILL. Charles G. Foote, Denver, Colo. Filed Dec. 14, 1903. Serial No. 185,140.



A rock-drill, the combination with a guide-shell and a casing slidable thereon, of a hollow cylinder mounted to rotate in the casing, a power-spring located in the cylinder, the latter being provided with a cam, and a hollow drill-holder entering the cylinder and having a projection engaging the cam of the rotary cylinder, whereby as the latter is rotated, the drill-holder is moved rearwardly against the power-spring and released.

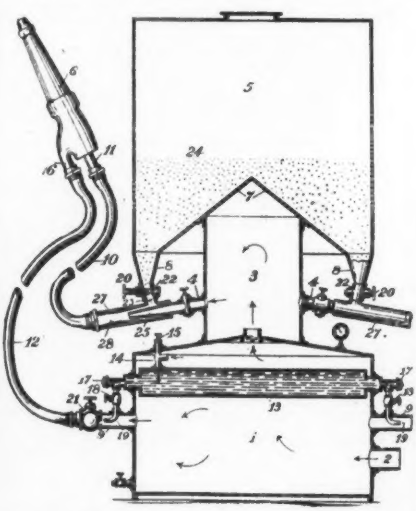
782,881. PNEUMATIC TRIPPING DEVICE FOR CLOTH-PILERS. Henry Smith, Baltimore, Md., assignor to Edward Alexander Griffith, Baltimore, Md. Filed Sept. 8, 1902. Serial No. 122,593.

783,024. VALVE FOR COMPRESSED GASES. Abraham B. Cox, Jr., New York, N. Y. Filed Aug. 26, 1903. Serial No. 170,798.

A valve, comprising an exteriorly-threaded shouldered casing adapted to project into a receptacle when attached thereto with the shoulder abutting with the receptacle the said casing having an orifice at its extreme inner end, a removable cap secured to the casing and provided with an outlet which forms a continuation of the casing-chamber, and a needle-valve held in the cap and casing and adapted to close the inner orifice of the casing.

783,025. CONVEYER-TRUNK. John M. Culver, Chicago, Ill. Filed Sept. 12, 1903. Serial No. 172,858.

783,218. SAND-BLAST APPARATUS. John D. Murray, San Francisco, Cal., assignor, by mesne assignments, to International Sand Blast Company, a Corporation of California. Filed May 12, 1904. Serial No. 207,705.



In sand-blast apparatus, a receiver containing air under pressure, a chamber containing sand or other abrading substance, flexible pipes or hose connecting from these vessels to an ejecting-nozzle, means to regulate the quantities of air and sand respectively, a water-inlet and means to supply water to the air-conducting pipe or hose and means to regulate the amount of water supplied thereto, combined and operating substantially as described.

783,151. PNEUMATIC-DESPATCH APPARATUS. Charles F. Stoddard, Boston, Mass., assignor to American Pneumatic Service Company, Dover, Del., a Corporation of Delaware. Filed Jan. 9, 1904. Serial No. 188,377.

783,219. PNEUMATIC TIRE. Harry A. Palmer, Erie, Pa. Filed Oct. 12, 1904. Serial No. 228,174.

783,261. AIR-BRAKE HANDLE. Wallace W. Fuller, Charleston, S. C. Filed Mar. 8, 1904. Serial No. 197,163.

783,289. PROTECTOR FOR PNEUMATIC TIRES. Emile Lapisse, Elbeuf, France. Filed Nov. 10, 1904. Serial No. 232,092.

783,469. CLAMPING DEVICE FOR PNEUMATIC TIRES. Maximilian C. Schweinert, West Hoboken, N. J., and Henry P. Kraft, New York, N. Y. Filed June 3, 1904. Serial No. 210,918.

783,507. EMERGENCY DEVICE. Fred B. Corey, Schenectady, N. Y., assignor to General Electric Company, a Corporation of New York. Filed June 16, 1904. Serial No. 212,778.

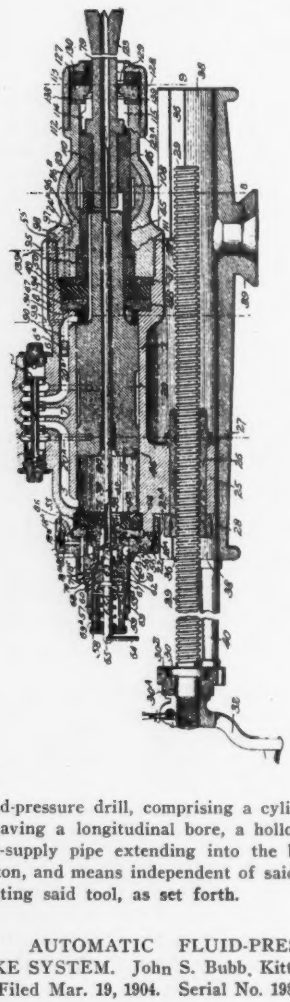
783,508. EMERGENCY-BRAKE. Fred B. Corey, Schenectady, N. Y., assignor to General Electric Company, a Corporation of New York. Filed June 16, 1904. Serial No. 212,779 .

783,528. PRESSURE-REGULATING VALVE. Ralph P. Kipp, Ossining, N. Y. Filed June 28, 1904. Serial No. 214,544.

783,720. PNEUMATIC TIRE. Frank E. Case, Canton, Ohio. Filed Sept. 29, 1904. Serial No. 226,471.

783,734. AIR-BRAKE VALVE. Edwin F. Richardson, Greenville, Pa. Filed May 26, 1904. Serial No. 209,836.

783,638. ROCK-DRILLING ENGINE. John G. Leyner, Denver, Colo. Filed Sept. 2, 1903. Serial No. 171,624.



A fluid-pressure drill, comprising a cylinder, a piston having a longitudinal bore, a hollow tool, a water-supply pipe extending into the bore of said piston, and means independent of said piston for rotating said tool, as set forth.

783,774. AUTOMATIC FLUID-PRESSURE BRAKE SYSTEM. John S. Bubb, Kittanning, Pa. Filed Mar. 19, 1904. Serial No. 198,934.

783,801. AIR-BRAKE. John Riley, Greensburg, Pa. Filed Apr. 27, 1904. Serial No. 205,224.

783,858. PNEUMATIC TIRE. Alfred Frey, Paris, France, assignor to Societe Anonyme des Pneumatiques Cuir Samson, Paris, France. Filed Sept. 12, 1904. Serial No. 224,194.